Technical Memorandum for the Dump Road Area Source Area Delineation Martin State Airport 701 Wilson Point Road Middle River, Maryland

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ACRONYMS

ATC anticipated typical concentration

BTEX benzene, toluene, ethylbenzene, and xylenes

 C_i effective solubility (mg/L) of chemical

 $C_{i(1\%)}$ 1% of effective solubility cis-1,2-DCE cis-1,2-dichloroethene

 C_D concentration of DNAPL saturation threshold (mg/kg)

CERCLA (federal) Comprehensive Environmental Response, Compensation, and Liability Act

CERCLIS CERCLA Information System

COPC chemical(s) of potential concern

cpm count(s) per minute

CPT cone penetration test(ing)

 C^{T} partitioning threshold concentration (mg/kg)

electron capture device

cVOC chlorinated volatile organic compound

DA Drum Area

DNAPL dense non-aqueous phase liquid

DPT direct push technology
DRA Dump Road Area
DRO diesel range organics

EM electromagnetic

ECD

ERA ecological risk assessment

 f_{oc} fraction of organic carbon (unitless)

ft/day feet per day

GRO gasoline range organics
GSP Greater Strawberry Point
H' Henry's Constant (unitless)
HHRA human health risk assessment

 K_d soil-water partition coefficient (milliliters per gram) (Kd = $K_{oc}f_{oc}$) K_{oc} organic carbon-water partition coefficient (milliliters per gram)

LNAPL light non-aqueous phase liquid
Lockheed Martin Corporation
MAA Maryland Aviation Administration

MDANG Maryland Air National Guard MCL maximum contaminant level

MDE Maryland Department of the Environment

MES Maryland Environmental Service

mg/kg milligram(s) per kilogram

µg/kg microgram(s) per kilogram

µg/L microgram(s) per liter

MIP membrane interface probe

MRC Middle River Complex

MSA Martin State Airport

NAA natural attenuation assessment

NAVD 1988 North American Vertical Datum of 1988

NPL National Priorities List
PA preliminary assessment

PAH polycyclic aromatic hydrocarbon

PCB polychlorinated biphenyl

PCE tetrachloroethene

PHA Petroleum Hydrocarbon Area
Ø effective porosity (unitless)

pCi/L picocurie(s) per liter
PID photoionization detector

ppm part(s) per million

ppmv part(s) per million per volume

pVOC petroleum volatile organic compound

RCRA (federal) Resource Conservation and Recovery Act

RDX cyclotrimethylene-trinitramine or Royal Demolition Explosive

RI remedial investigation

 ρ_b dry soil bulk density (grams per cubic centimeter) ρ_N DNAPL density (grams per cubic centimeter)

SP Strawberry Point

 S_r threshold DNAPL saturation SVOC semivolatile organic compound

TCE trichloroethene

TCE_{EO} trichloroethene equivalent

TCLP toxicity characteristic leaching procedure

Tetra Tech, Inc.

 θ_{w} water filled porosity (unitless) from moisture content

 θ_a air filled porosity (unitless)
TPH total petroleum hydrocarbon

TT Median Area Taxiway Tango Median Anomaly Area
USEPA U.S. Environmental Protection Agency

VC vinyl chloride

VOC volatile organic compound

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Section 1 Introduction

This technical memorandum for the Dump Road Area (DRA) site at Martin State Airport (MSA) in Middle River, Maryland, identifies and describes source areas of volatile organic compounds (VOCs) found in soil and groundwater at the site. Geophysical survey results, test pit results, and chemical analytical results of soil and groundwater samples collected from soil borings, test pits, and monitoring wells are used to assess and describe the source areas, to identify data gaps, and to evaluate actions required to further characterize the source areas. Figure 1-1 shows the locations of Martin State Airport and the Dump Road Area.

Lockheed Martin Corporation (Lockheed Martin) is also conducting environmental investigations at Frog Mortar Creek, the Greater Strawberry Point (GSP) area, and the Main Terminal area of Martin State Airport. However, these sites are being addressed separately from the Dump Road Area and are not included in this memorandum. Tetra Tech, Inc. (Tetra Tech) prepared this document for Lockheed Martin Corporation as part of continuing environmental investigations of Martin State Airport conducted under the oversight of Maryland Department of the Environment's (MDE's) Controlled Hazardous Substances Enforcement Division, formerly the state Superfund program. The objectives of the study are to identify, assess, and describe volatile organic compound source areas at the Dump Road Area, identify data gaps, and evaluate actions required to further characterize the source areas. This technical memorandum is organized as follows:

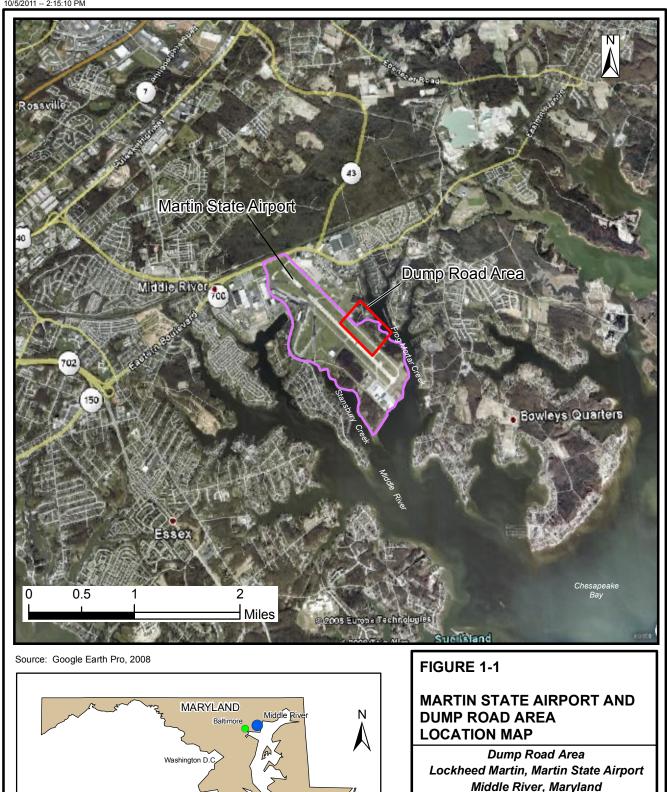
<u>Section 2—Site Background</u>: Presents a brief overview and history of the site and describes surface and subsurface conditions observed in the field during investigations conducted to date. This section also describes the regional geology and hydrogeology, as determined from site soil borings and the scientific literature. Investigations at Dump Road Area to date are also discussed in this section.

<u>Section 3—Evaluation and Interpretation of Investigation Results</u>: Presents the technical approach to the investigation and describes the methodologies used.

<u>Section 4—Source Areas' Nature and Extent</u>: Presents the study results.

Section 5—Summary and Recommendations: Summarizes the study results.

<u>Section 6—References</u>: Cites references used to compile this memorandum.



Middle River, Maryland

10/05/11 MP



Section 2 Site Background

2.1 SITE DESCRIPTION

2.1.1 Location

Martin State Airport (MSA) is at 701 Wilson Point Road in Middle River, Maryland, and is bounded by Frog Mortar Creek to the east and Stansbury Creek to the west (Figure 2-1). Both creeks are tidal tributaries of the Chesapeake Bay and join the bay at the south side of the airport. The Dump Road Area (DRA) is in the southeastern portion of MSA and is bounded by Frog Mortar Creek to the east and the airport runway to the west. Although the area has been investigated since the 1990s, Lockheed Martin Corporation (Lockheed Martin) recently designated the site as the DRA to distinguish it from other MSA areas under investigation (e.g., Frog Mortar Creek, Strawberry Point [SP], Greater Strawberry Point [GSP], and the Main Terminal Area).

2.1.2 History

The current MSA property was part of the Glenn L. Martin Company's original 1,260-acre property, which previously included both the MSA, and the manufacturing portion of the original facility now known as Lockheed Martin's Middle River Complex (MRC) (see Figure 2-1). In the spring and summer of 1929, the Glenn L. Martin Company purchased six parcels of land from private landowners. During the 1940s and 1950s, nine additional parcels were acquired from private landowners; together these parcels comprise the current areas of MSA and the MRC.

In 1932, the B-10 bomber was one of the first aircraft produced at the Glenn L. Martin Company Baltimore facility. Three runways, Hangars 1–3, and the airport administration building were built at the MSA in 1939 and 1940. Hangars 4–6 and the SP Hangar were completed in 1940 and 1941. After World War II, commercial transports and jet aircraft were produced at the manufacturing portion of the facility. In July 1955, the Maryland Air National Guard (MDANG) 104th Tactical Fighter Group began leasing property from the Glenn L. Martin Company. On April 1, 1960, the 135th Tactical Airlift, previously based in Baltimore, was transferred to MSA,

and by October 1962, the 104th Tactical Fighter Group had been reorganized and designated the 175th Tactical Fighter Group.

The Glenn L. Martin Company consolidated with American Marietta Corporation in September 1961 to form Martin Marietta Corporation. On September 20, 1975, the Maryland Aviation Administration (MAA) purchased 747 acres that are now used as the airfield, of which 175 acres in the northeastern portion are now leased to MDANG. In 1995, Lockheed Corporation and Martin Marietta merged to form Lockheed Martin Corporation. Lockheed Martin, northwest of the airport, occupies 338 acres of the original 1,260 acres at the MRC, and is currently conducting environmental investigations and remediation at MSA and the MRC.

2.1.3 Current Conditions

MAA currently operates MSA on behalf of the Maryland Department of Transportation. MSA has an administration building (Main Terminal building), aircraft hangars, a 7,000-foot long runway, several taxiways, and the SP Hangar. MAA manages more than 130,000 square feet of heated hangar space and 190 smaller aircraft T-hangars. The southwestern portion of MSA contains numerous aboveground fuel storage tanks for Jet A and Avgas 100LL fuels. MSA is also home to more than 20 commercial tenants providing fuels and lubricants, helicopter avionics repair, and flight instruction, in addition to hosting Baltimore County Police aviation and marine units and the Glenn L. Martin Museum (MAA, 2009).

The DRA consists mostly of mowed grass surrounding Taxiway Tango and the runway, heavily wooded areas in the northern, eastern, and southeastern portions of the site, and open meadows in the east–central and southeastern portions of the site. The DRA also includes portions of Taxiway Tango and the airport runway and two small ponds (Ponds 1 and 2). Site topography is generally flat and slopes gently to the northeast toward Frog Mortar Creek. Along the Frog Mortar Creek shoreline lies a steeply sloped embankment comprised of fill placed there as part of airport construction.

2.1.4 Land Use

MSA is generally characterized as a moderately developed tract in a largely suburbanized, moderate density, populated setting. Land use surrounding MSA is, to a significant degree, a combination of mixed suburban, industrial, commercial, lightly- to moderately-developed tracts,

and woodland tracts. The northern boundary of MSA is bordered by Eastern Boulevard (Maryland Route 150) and AMTRAK railroad lines.

Undeveloped woodland tracts and low-density residential properties are north of MSA and the Amtrak line. The MSA's eastern, southern, and western boundaries are bordered by Frog Mortar Creek and Stansbury Creek, which are wide, brackish, tidal tributaries of the middle Chesapeake Bay. The MRC lies along MSA's northwestern boundary. The Old Navy Depot–Bengies (Plant 2) is across from the MSA on Eastern Avenue. Low- to medium-density residential and light commercial land uses (e.g., shopping centers, convenience stores, restaurants, etc.) are beyond the creeks east, south, and west of MSA. Farther east and west of MSA are the high-density residential communities of Bengies Corner and Hawthorne Park. The town of Middle River is approximately 1.5 miles northwest of MSA.

2.1.5 Climate

The MSA has a humid, temperate climate, with hot humid summers and relatively mild winters. The Middle River, Maryland area receives an average of 42 inches of precipitation annually, distributed evenly throughout the year. Rainfall normally occurs in the summer as showers and thunderstorms. In winter, precipitation is typically light to heavy rainfall or snow. Tropical storms in late summer and fall, and occluded, meso-scale frontal systems (i.e., coastal low pressure systems) in winter and spring occasionally provide short-term above average precipitation.

2.1.6 Physiography

MSA is in the western shore of the Coastal Plain physiographic province. The Coastal Plain consists of sediments composed of alluvium from the Pleistocene Epoch and the Potomac Group from the Cretaceous Period. Coastal Plain sediments begin at the Fall Line and follow a regional dip to the southeast at approximately 110 feet per mile (Hansen and Edwards, 1986). The Fall Line is the division between the Piedmont and Atlantic Coastal physiographic provinces. Its name refers to an imaginary line connecting changes in stream flow characteristics between the hard-rock upland areas of the Piedmont and the soft-sediment lowland areas of the Coastal Plain. The Coastal Plain is generally characterized by low topographic relief. However, steep embankments and hills are found along stream channels, rivers, and Chesapeake Bay.

2.1.7 Topography

Most of MSA's land surface is generally flat to gently sloping in the areas of the runway, taxiways, and surrounding support operations. The MSA runway forms a trending topographic ridge, or drainage divide, that slopes gently from the northwest end to the southeast end. Runway elevations range from slightly more than 20 feet above the North American Vertical Datum of 1988 (NAVD 1988) at the northern end to slightly more than 10 feet above NAVD 1988 at the southern end. The land slopes away from the runway toward Frog Mortar Creek to the northeast, and Stansbury Creek to the southwest.

In the northern portion of the DRA, land elevations range from approximately 11 feet above NAVD 1988 near the runway to approximately seven feet above NAVD 1988 at Pond 2. In the southeastern portion of the site near Frog Mortar Creek, land elevations are approximately 20 feet above NAVD 1988 at a mounded area near the creek embankment. The elevation at the top of the creek embankment ranges from approximately 10 feet above NAVD 1988 at the northern portion of the DRA to approximately 20 feet above NAVD 1988 in the southern portion. Land surface elevation at the Frog Mortar Creek shoreline is near zero feet, relative to NAVD 1988.

2.1.8 Surface Water Hydrology

The eastern, southern, and western boundaries of MSA are bordered by Frog Mortar Creek and Stansbury Creek, which are wide, brackish, tidal tributaries of the middle Chesapeake Bay. Surface water runoff from MSA enters these creeks via localized gullies in the eastern and western undeveloped portions of the site, or via storm sewers that drain the airport runway, taxiways, and developed portions of the facility. MSA encompasses 47 drainage areas in three watersheds, forming a total drainage area of 700 acres (MAA, 2008). The airport drainage areas range from seven to more than 170 acres.

In the DRA, six drainage areas drain the runway, taxiways, and wooded areas, discharging to Frog Mortar Creek on the east side of MSA. The DRA has two small ponds, wetlands, and a storm water management pond is near the Fire Pump House in the western portion of MSA. These ponds and the wetland in the DRA are contained within each drainage area and do not discharge to Frog Mortar Creek. The storm water pond near the Fire Pump House discharges to the upper reaches of the Stansbury Creek tidal area.

All storm water runoff originating from MSA discharges to outfall areas that are monitored monthly to ensure that no oily discharges to surface water occur. Secondary containment drains are also routinely inspected and emptied of storm water. The facility maintains a General National Pollutant Discharge Elimination System Permit (No. MDR 05501, General Discharge Permit No. 05-SF-5501), with an effective date of November 12, 2004 and an expiration date of November 12, 2009. However, the current permit remains in effect because the Maryland Department of the Environment (MDE) has administratively extended it until they issue a new general permit.

The site's general industrial permit has no monitoring requirements. However, limited monitoring is performed as part of the separate municipal storm-sewer system permit required for the federal Illicit Discharge Detection and Elimination program. This limited monitoring includes laboratory analysis for ammonia, dissolved oxygen, surfactants, fecal coliform, potassium, water temperature, conductivity, pH, and fluoride concentrations in monitored outfalls during annual inspections. Visual inspections are routinely performed and annual reports are submitted to MDE.

2.1.9 Geology and Hydrogeology

MSA is in the western shore of the Coastal Plain physiographic province. Regional and local studies (Vroblesky and Fleck, 1991; Chapelle, 1985) indicate that MSA lies on the Patapsco Formation. This formation consists of complex and interbedded mixtures of gray, brown, and red sands, silts, and clays originating from sediment deposition in a low coastal plain traversed by low-gradient meandering streams. Below the Patapsco Formation lies a regionally extensive thick-clay confining-unit known as the Arundel Formation. It is a massive and probably impermeable unit underlying the site and surrounding area.

The Arundel Formation outcrops northwest of the site and dips and thickens to the southeast. The Arundel Formation extends as far east as Cambridge, Maryland, where it is more than 600 feet thick. Regional lithologic information indicates that the Arundel Formation may be up to 150 feet thick at MSA (Vroblesky and Fleck, 1991; Chapelle, 1985). The formation probably acts as an impermeable barrier to the downward movement of any constituents found in the surficial aquifer. The base of the Arundel Formation (i.e., the top surface of the deeper Patuxent Formation) is approximately 225 feet below NAVD 1988 near MSA (Vroblesky and Fleck, 1991;

Chapelle, 1985). The depth to the base of the Arundel Formation may therefore range from 235-255 feet below grade at MSA.

Below the Arundel Formation is the Patuxent Formation. The Patuxent Formation is a multi-aquifer unit comprised of various interbedded sand and silt/clay layers and rapid changes of deposited material types over short distances. Permeable sand-rich units range from bounded sand sheets to isolated sand bodies (Glaser, 1969). In the MSA area, potentiometric maps of the Patuxent Formation indicate groundwater flows to the south and southwest, in response to industrial wells withdrawing water southwest and west of the site (Chapelle, 1985 and Curtin, 2006).

2.1.10 Vicinity Subsurface Conditions

An extensive and ongoing subsurface investigation continues at the DRA. Less extensive environmental investigations have been conducted at SP and GSP, which are south and southwest of the DRA. As part of the DRA investigation, numerous shallow and deep soil borings have been advanced to collect soil samples for subsurface lithologic information. Synoptic water level measurements, single-well permeability tests, and pumping tests have been conducted to characterize subsurface hydraulic conditions at the DRA. Figure 2-2 is a fence diagram of the generalized geology at the DRA, based on the lithology encountered in the course of subsurface investigations.

Early studies at the DRA indicated that the subsurface hydrogeology is comprised of a surficial aquifer (i.e., the Patapsco Formation) containing highly heterogeneous mixtures of unconsolidated sand, silt, gravel/sand mixtures, and clay. A layer of fill, consisting of heterogeneous sand, silt, and clay, overlies these native sediments. For data evaluation and correlation, the surficial aquifer is divided into upper, intermediate, and lower surficial aquifer zones. The lower surficial aquifer zone is encountered up to approximately 45–73 feet below NAVD 1988, and overlies at least several feet of stiff, dense clay.

A deep groundwater study investigated the lithology beneath the lower surficial aquifer in the DRA of MSA (Tetra Tech, Inc. [Tetra Tech], 2009a). Lithologic data from four deep wells indicate six to 40 feet of clay beneath the lower surficial aquifer. Deep well logs also indicate

alternating sand and silt aquifers and clay aquitards beneath the lower surficial aquifer. These sandy units are referred to as the deep confined aquifer zones.

2.2 AREAS OF CONCERN

During the 1930s through 1960s, three pits are reported to have been used to dump spent battery acid, acid-type strippers, and other acidic solutions. Dredge spoils and construction debris associated with industrial operations were also reported to have been placed in the pits. MDE found only two of the three pits during site visits made as part of a 1989 preliminary assessment (PA). MDE referred to the two pits as ponds in the PA; these pits were later named Acid Pit #1 (Pond 1) and Acid Pit #2 (Pond 2) in subsequent studies. Pond 1 and Pond 2 are shown in Figure 2-3. Additionally, aerial photographs from 1952 and 1957 reviewed during a 1996 DRA investigation (i.e., the July 1996 expanded investigation) show an open "burial area" or "dump" adjacent to what is now Taxiway Tango.

In July 1991, four drums containing dried zinc-chromate paint were uncovered during installation of underground electric cables adjacent to Taxiway Tango (Figure 2-3). This discovery prompted MDE to order MAA to conduct additional studies of the Taxiway Tango area. Early investigations from 1991–1996 identified four areas of concern known as the Taxiway Tango Median Anomaly Area (TT Median Area), the Drum Area (DA), two ponds (Pond 1 and Pond 2), and the Petroleum Hydrocarbon Area (PHA). These four areas are shown in Figure 2-3. Brief descriptions of these four areas follow:

- Taxiway Tango Median Anomaly Area—Located between Taxiway Tango and the airport runway, northwest of Taxiway D, four buried drums containing dried zinc-chromate paint were unearthed and removed from this area in 1991. A construction drawing indicates fill and trash, and an initial geophysical survey indicates several electromagnetic (EM) anomalies, suggesting buried metal.
- *Drum Area*—In the forested area near wells MW-2 and MW-5, northeast of Taxiway Tango, several drums were uncovered when surface vegetation was cleared during a 1996 site investigation.
- Two ponds—Historical records indicate that acids may have been discharged at the present location of these ponds (approximately 450 feet and 600 feet northeast of Taxiway Tango, respectively) sometime during the 1930s through the 1960s. A third pond is shown in the area on a U.S. Geological Survey topographic map (photo-revised in 1985) for the PA, but MDE could not locate a third pond during the 1989 site visits.

Petroleum Hydrocarbon Area—The PHA is approximately 200 feet west of the ponds.
 Petroleum hydrocarbons were encountered while drilling a soil boring during the 1996 site investigation.

These four areas became the focus of subsequent studies when chemical constituent impacts to soil, pond sediment, and groundwater became apparent. MAA first investigated Frog Mortar Creek in 1998.

From 1999–2010, Lockheed Martin conducted a remedial investigation (RI) (Tetra Tech, 2012a) and a supplemental RI (Tetra Tech, 2011a) to further delineate the extent of soil, groundwater, and pond sediment chemical contamination indicated by earlier studies at MSA. Through geophysical surveys, membrane interface probes (MIPs), test pits, soil borings, and chemical analyses of soil and pond sediment samples the RI identified large areas of buried fill and debris, and surface and subsurface soil contamination in and around the buried fill material and in pond sediment. Buried fill and debris were estimated present over approximately 25 acres of the DRA.

The fill material consists of soil, stained soil, and debris, the latter of which is comprised of concrete rubble and disposed industrial items (e.g., batteries, deteriorated drums, tires, paint cans, burned items, sludge, buckets, glass, wood, etc.). Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and several metals were detected in soil at concentrations exceeding human health risk screening levels. Chlorinated VOCs (cVOCs) (trichloroethene [TCE] and its degradation products), petroleum VOCs (pVOCs) (e.g., benzene, toluene, etc.), and metals were also detected in surficial aquifer groundwater at concentrations exceeding Maryland groundwater and drinking water standards.

2.3 PREVIOUS INVESTIGATION HISTORY

Numerous environmental investigations have been conducted at the DRA since 1991. Summaries of the historical subsurface investigations at the DRA are in Table 2-1 and in the sections below. Studies of Frog Mortar Creek are not included in this memorandum because they are being addressed under a separate investigation program. Details of Frog Mortar Creek studies can be found in Tetra Tech (2012b).

2.3.1 MDE Site Inspections

Environmental investigations of MSA began in the mid-1980s when MDE conducted site inspections related to stored drums and a reported chemical dump. In 1985, MDE inspected MSA and found approximately 200 55-gallon drums containing acetone, creosote, and chrome paint in the storage yard behind the maintenance building (MDE, 1989) (see Figure 2-4). The drums were stored on bare ground, an arrangement MDE considered haphazard. MDE issued a "Site Complaint" on July 17, 1985 requiring the MAA to secure, sample, and remove all waste material from the site within 30 days of the permit.

MDE visited MSA in 1988 in response to an anonymous telephone call claiming that a large chemical dump had operated at a portion of SP during the war (i.e., World War II), and that a large number of drums containing zinc cyanide were buried there (MDE, 1989). MDE was unable to confirm these claims during site visits and interviews with past and current facility workers. However, during an interview conducted for the 1989 PA (MDE, 1989), a former maintenance chief for the Glenn L. Martin Aircraft Company reported to MDE that the SP area, or an adjacent northwestern area, is the former location of a power station. The PA offers no other details regarding the power station.

2.3.2 1989 Preliminary Assessment

PAs are limited-scope investigations initiated in response to requirements of the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, and the Superfund Amendments and Reauthorization Act of 1986. The U.S. Environmental Protection Agency (USEPA) and/or state agencies maintain a database of information about hazardous waste sites on the *National Priorities List* (NPL), or sites being considered for the NPL. The CERCLA Information System (CERCLIS) is USEPA's computerized inventory of potential hazardous waste sites. Regional USEPA offices, state agencies, and/or citizens may file a PA petition for a site; that site is then entered into the CERCLA process and subsequently investigated.

MDE conducted a PA of MSA in 1989 under contract to the USEPA (MDE, 1989) and identified several areas of concern (Figure 2-4). An area containing the location of three former pits (two of which are now referred to as Ponds 1 and 2) was identified in the PA as a major area of concern at MSA. These pits were reported to have been used in the past to dispose of acids. The PA also

addresses the 1988 anonymous telephone call and associated claims regarding the alleged SP chemical dump and buried drums (discussed in Section 2.3.1).

The PA identified two other environmental issues at MSA: (1) the maintenance-building yard drum-storage area (also discussed in Section 2.3.1), and (2) three buildings previously used for a nuclear generator. During interviews conducted for the PA, MAA reported that in late 1985, subsequent to MDE's 1985 inspection, the drums at the maintenance yard area had been removed and their contents disposed of by a waste contractor. Only three empty drums were found in the maintenance yard area during the 1989 PA. Adequate documentation regarding the closure of the nuclear generator buildings was not available during the PA. The MDE Hazardous Waste Enforcement Division and Center for Radiological Health was therefore notified so follow-up inspections could be performed.

The PA reported that the U.S. Geological Survey topographic map for MSA shows an area labeled as "sandpits" adjacent to Frog Mortar Creek. The topographic map shows three open ponds in this "sandpits" area. However, MDE only found two of the ponds during the PA site visits. The MSA facility manager interviewed during the PA stated that these ponds were known as "acid pits." The MSA facility manager stated that former aircraft facility employees had told him that spent battery acid, acid-type strippers, and other acidic solutions had been routinely dumped into the three ponds. The former aircraft facility employees also told the MSA facility manager that dredge spoils and construction debris had been disposed of in these ponds.

At the time of the 1989 PA, MSA was regulated under federal Resource Conservation and Recovery Act Corrective Action regulations. The PA recommended no further remedial action under CERCLA. However, it also states that this classification could be reconsidered if new information indicated a need for additional studies.

2.3.3 1991 Drum Discovery and Geophysical Survey

In July 1991, four drums were uncovered during installation of underground electric cables adjacent to (i.e., west of) Taxiway Tango (Figures 2-3 and 2-5). These drums contained dried zinc-chromate paint and were removed by MAA. A subsequent file review by MDANG produced a map and soil profiles of the area that were prepared in 1956 by the U.S. Army Corps of Engineers.

The soil profiles indicate an area of fill and trash approximately 900 feet long and five feet deep underlying Taxiway Tango. This discovery prompted MAA to conduct a geophysical survey of a 200- by 1,600-foot area adjacent to Taxiway Tango between the taxiway and the runway (Handex, 1992). The locations of the 1991 geophysical survey study area, along with the 1956 soil boring locations where fill and trash were encountered, are shown in Figure 2-5; the results of the geophysical survey are shown in Figure 2-6.

As shown in the figure, numerous geophysical anomalies were detected during the survey, indicating possible buried metal within the survey area. The top surfaces of the metal material were estimated to be at shallow depths, between two and three feet below grade. The survey report recommended excavating several test pits to inspect the areas of the suspected buried metal.

2.3.4 1994 Preliminary Site Investigation

Upon review of the geophysical survey report, MDE asked MAA to further investigate and remediate the location where the four buried drums had been found (MDE, 1992). MAA conducted a records search and preliminary site investigation in early 1994 (Maryland Environmental Service [MES, 1994]). The field investigation included advancing 11 soil probes using direct-push technology (DPT), chemical analyses of 15 soil gas and 16 soil samples, and installation and sampling of three piezometers (PZ-1, PZ-2, and PZ-3). One piezometer was west of the geophysical survey area and the other two were near Taxiway Tango. The sampling locations and piezometers are shown in Figure 2-7. The locations of PZ-1, PZ-2, and PZ-3 are also shown in Figure 2-3.

Soil gas samples were analyzed for total petroleum hydrocarbons (TPH), gasoline-range organics (GRO), and the pVOCs, benzene, toluene, ethylbenzene, and xylenes (BTEX). Soil samples were analyzed for toxicity characteristics leaching procedure (TCLP) metals, TCLP VOCs, pH (a measure of acidity or alkalinity), ignitability, and sulfide. Groundwater samples were analyzed for VOCs, inorganics, and water quality parameters (e.g., alkalinity, nitrate, nitrite, turbidity, etc.).

Methyl-ethyl-ketone and cVOCs such as tetrachloroethene (PCE), TCE, and vinyl chloride (VC) were detected in soil samples. Inorganic concentrations in soil samples were less than the TCLP concentrations used to determine if a material is hazardous, in accordance with 40 *Code of Federal Regulations* 261. Several VOCs exceeded USEPA maximum contaminant levels (MCLs) for safe

drinking water by more than three orders of magnitude (i.e., by more than a factor of 1,000). Single-well permeability tests on the three shallow piezometers provided an estimated average hydraulic conductivity of 0.33 feet per day (ft/day).

2.3.5 1994 Confirmation Investigation

MAA conducted a confirmation investigation in 1994 to further delineate the extent of contamination at the buried drum site (MES, 1995). The field program consisted of the following activities:

- advancement of 85 shallow soil borings to depths of 2–16 feet below grade
- chemical analyses of 75 soil samples for VOCs, SVOCs, inorganics, and TPH; several soil samples were analyzed for TCLP metals
- chemical analyses of three soil samples from monitoring well borings
- installation of three groundwater monitoring wells (MW-1, MW-2, and MW-3)
- implementation of single-well permeability tests (i.e., slug tests) on these wells
- chemical analyses of groundwater samples from three wells and 23 temporary wells for VOCs, SVOCs, metals, TPH, sodium, and chloride
- chemical analyses of a surface water sample from an acid pit (now referred to as Pond 1)

Soil boring locations are shown in Figure 2-8. The investigation indicated that higher concentrations of contaminants in soil correlated with geophysical anomalies identified in the 1991 survey. Elevated concentrations of TPH, VOCs, and SVOCs were detected in shallow groundwater samples. Maximum concentrations of TCE, *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and VC detected in one probe groundwater-sample, approximately 200 feet east of Taxiway Tango (in an area that appears to be between wells MW-26S/I and MW-4) exceeded MCLs by factors ranging from more than 400 times for *cis*-1,2-DCE to more than 1,000 times for VC.

BTEX were also detected in groundwater samples, with benzene concentrations exceeding its MCL in five probe groundwater samples. Concentrations of chromium exceeded the MCL at four groundwater sampling locations. Concentrations of lead and nickel in groundwater exceeded MCLs at nearly all sampling locations. The investigation results were used to simulate the fate and transport of groundwater VOC contamination via numerical modeling.

2.3.6 1996 Expanded Investigation

In 1996, MAA expanded its investigation of soil and groundwater quality to include the fill area between Taxiway Tango and Frog Mortar Creek (MES, 1996). This investigation involved the area east of Taxiway Tango, including the two former acid pits (i.e., ponds) that had been identified in the 1989 PA. These sampling results were used to evaluate potential risks to human health.

Aerial photographs from 1952 and 1957 reviewed during the expanded investigation show an open "burial area" or "dump" adjacent to what is now Taxiway Tango. The photographs also show the area of "Acid Pit #1" (i.e., Pond 1). Thick smoke in the photo appears to emanate from the vicinity of "Acid Pit #1." During the expanded investigation, 25 DPT soil borings and five manual soil-probe borings were advanced in this area to depths ranging from 6–22 feet below grade.

Soil samples were screened in the field for VOCs using a mobile laboratory, and 15 samples with elevated concentrations of VOCs were submitted to a fixed-base laboratory for chemical analyses. Ten DPT groundwater samples were collected and screened in the field before being submitted to a fixed laboratory for chemical analyses. Three groundwater monitoring wells (MW-4, MW-5, and MW-6) were also installed as part of this investigation (these wells are shown in Figure 2-3). Groundwater samples were collected from six wells and three piezometers and analyzed for VOCs, SVOCs, and metals. One composite sediment sample each was collected from Acid Pit # 1 and Acid Pit #2 (i.e., two ponds) and analyzed for TCLP parameters for organics and inorganics.

A void was encountered while advancing soil boring B-8. Neither the soil boring log for location B-8 nor the MES report clearly indicate details of the void; however, the boring log indicates that the void may be from a buried tank or container at depths of eight to 13 feet. The soil lithology column in the log shows no lithology from two to eight feet, but soil samples from five and 10 feet are described, and continuous lithology is shown in the log from eight to 14 feet (the bottom depth of the soil boring). The MES report estimates that the void is 11 feet long.

Soil at the 12 to 14 feet depth interval in boring B-8 was reported as having a strong odor, and had a high field reading (greater than 2,500 parts per million [ppm]) for total VOCs using a portable photoionization detector (PID). The boring log also indicates that pure product was observed at this depth. Soil samples from a depth interval of 12 to 14 feet (as noted in the log)

were submitted to both the field laboratory and an off-site analytical laboratory for chemical analyses (note, however, that Table 1 in the 1996 expanded investigation report lists the sampling depth as 10 to 14 feet). The field laboratory analyses of soil from boring B-8 found high concentrations of TCE (6.2 milligrams per kilogram [mg/kg]) and TPH-diesel-range organics (DRO) (19,000 mg/kg). However, the off-site laboratory analyses reported a much lower TCE concentration of 130 micrograms per kilogram (µg/kg), which is equivalent to 0.130 mg/kg.

As part of the same investigation, free product was observed at depths of four to seven feet in boring B-15, which is in the dirt access road near the PHA. A VOC reading of 9,300 ppm was recorded for soil at six feet below grade, which is at the groundwater table. This was presumably petroleum-related product of light non-aqueous phase liquid (LNAPL). A sample from four to seven feet (as indicated on the log, but Table 1 in the 1996 report shows seven to 10 feet) was collected for chemical analyses. The laboratory reported TCE in the boring B-15 soil sample at $140 \mu g/kg$ and xylenes at $13,000 \mu g/kg$ (13 mg/kg).

While clearing vegetation for sampling access, deteriorated drums were discovered on the ground northeast of Taxiway Tango, in the area now known as the DA (i.e., Drum Area; see Figure 2-3). The contents tested TCLP-hazardous for chromium and were collected for off-site disposal. Sediment samples were also analyzed using TCLP methods (TCLP extraction and subsequent analyses). Results from Acid Pit #1 (Pond 1) exceeded the TCLP limit for cadmium and TCE. TCE was also detected at a concentration of 63,000 micrograms per liter (µg/L) in a groundwater sample from newly installed well MW-5, downgradient of the DA.

2.3.7 1999 Groundwater Monitoring Well Surveying and Sampling

Lockheed Martin first evaluated the site in March 1999, surveying and sampling the six existing groundwater monitoring wells MW-1 through MW-6 and piezometer PZ-2 (Tetra Tech, 1999). The locations of these wells and piezometer are shown in Figure 2-3. Previously installed piezometers PZ-1 and PZ-3 could not be located during the 1999 study.

The study objectives were to provide horizontal locations and casing elevations for the wells and piezometer using established vertical and horizontal datum, and to obtain updated chemical data on groundwater quality and groundwater flow direction at the DRA. Additionally, the MDE well database was searched to provide details on possible water-supply wells within a half-mile of the

DRA. Horizontal survey coordinates for the wells and piezometer were obtained using the Maryland State Plane System. Elevations were surveyed to the nearest 0.01 foot. Groundwater samples were analyzed for VOCs, SVOCs, total and dissolved metals, TPH-DRO, and TPH-GRO.

Consistent with previous findings, TCE and cis-1,2-DCE, and VC were detected in selected monitoring wells at concentrations exceeding Maryland groundwater standards and federal MCLs. TCE was detected at all wells/piezometer except MW-4, with concentrations ranging from 10 µg/L at PZ-2 to 59,000 µg/L at MW-5 (duplicate sample concentration). The second highest TCE concentration, 380 µg/L at MW-3, was two orders of magnitude less than the TCE concentration at MW-5. SVOCs (e.g., naphthalene, phenol, 2-methylphenol, and 4-methylphenol) were only detected at MW-5. High concentrations of TPH-GRO (46,000 µg/L) and TPH-DRO (2,800 µg/L) were detected at MW-5. For dissolved metals, only dissolved beryllium (at MW-2, MW-5, and MW-6) and dissolved cadmium (at MW-2 and MW-5) exceeded MCLs. Detection of elevated VOC concentrations in the existing monitoring wells led to further investigation of the site to identify possible chemical source areas.

Seventeen upgradient wells were identified within one-half mile of the DRA. Fifteen are domestic wells and two are industrial wells. The closest wells are on the eastern shore of Frog Mortar Creek (across from the DRA) and on the MDANG property north of the DRA. Well depths range from 50 to 199 feet below grade.

2.3.8 2000 Source Identification and Assessment Program

From March to May 2000, the source identification and assessment program (Tetra Tech, 2000), further investigated the four areas previously identified by MAA as possible chemical-release areas (see Section 2.2). Each possible chemical source area was investigated through a combination of excavations, localized trenching, drilling of soil borings, and sampling and laboratory chemical analyses of soil, sediments, and groundwater samples. Trench and sampling locations are shown in Figure 2-9.

Soil in the TT Median Area was investigated by excavating six test pits and collecting 42 soil samples for chemical analyses (beginning sample designations TT-EX1 through TT-EX6). Soil in the DA was investigated by excavating a 10- by 10-foot area, excavating four trenches/cross-trenches, and collecting 21 soil samples from the excavations for chemical

analyses (beginning sample designations DA-T1 through DA-T4, and DA-E1) and from five nearby locations where 11 deteriorating drums had been found on the ground (samples DA-NC1-1, DA-NC2-1, and DA-ES1-1 through DA-ES3-1).

The contents of three drums were sampled. The contents of two were characterized as non-regulated material and were transported off-site as non-hazardous waste. The third drum contained soil coated with yellow-green paint. Its contents were characterized as hazardous waste due to chromium, and it was transported off-site under a "Uniform Hazardous Waste Manifest."

Shallow soil in the area of Pond 1, Pond 2, and the PHA were investigated by collecting 15 soil samples at depths of 11 feet or less (typically four to five feet deep) from drilled soil borings (borings EP1-SB1 through EP1-SB3 for Pond 1; EP2-SB1 through EP2-SB4 for Pond 2; and PHA-SB1 through PHA-SB5 for the PHA). Groundwater samples were also collected from each of the pond area and PHA soil borings. Additionally, four pond sediment samples (two from each of two ponds) were collected. The PHA soil borings were around soil boring B-15 (from the 1996 confirmation investigation), which contained petroleum hydrocarbons.

cVOCs and pVOCs were detected in soil and groundwater during this investigation. VC was the only VOC in soil or pond sediment detected above the USEPA industrial soil risk-based criteria, which were used to compare the results for this study. The VC exceedance was for a soil sample collected at the PHA.

pVOCs were primarily detected in soil samples from TT Median Area Excavations 1 through 3 and 6. Concentrations of pVOCs were low at the DA. Low concentrations of TCE and other cVOCs were detected in TT Median Area Excavations 1 through 3. TCE and other cVOCs were also detected in DA soil samples.

At the DA, TCE was detected at maximum concentrations of 7,000 μg/kg in a trench soil sample, and 6,500 μg/kg in a sample collected below deteriorated drums. Low concentrations of cVOCs and pVOCs were detected in soil samples collected around the ponds. At the PHA, high concentrations of pVOCs (primarily xylenes and naphthalene at maximum concentrations of 260,000 μg/kg and 100,000 μg/kg, respectively) and moderate concentrations of cVOCs (maximum TCE, cis-1,2-DCE, and VC concentrations of 4,000 μg/kg, 20,000 μg/kg, and

5,000 μg/kg, respectively) were detected in soil samples. Four inert bombs (ranging from 100 to 2,000 pounds) were also uncovered at TT Median Area Excavation 5, and were removed from MSA by explosive ordnance disposal personnel from Fort Meade, Maryland.

Concentrations of cVOCs (TCE, carbon tetrachloride, VC, etc.) and pVOCs in groundwater samples collected near the ponds and at the PHA exceeded Maryland groundwater standards by several orders of magnitude. The pH measurements for soil and groundwater around the ponds and at the PHA generally indicate slightly acidic to slightly alkaline conditions; pH ranges from 6.1 to 9.4 standard units for most samples. Stronger acidic conditions are indicated in soil (pH = 4.7 for samples EP2-SB1-5 and EP2-SB2-1) and groundwater (pH = 4.0 for EP2-SB2-GW) on the southern side of Pond 2.

Sediment samples from Pond 1 contained high concentrations of both cVOCs and pVOCs. Notable maximum VOC concentrations in Pond 1 sediment include PCE at 3,300 μg/kg, TCE at 69,000 μg/kg, *cis*-1,2-DCE at 34,000 μg/kg, toluene at 350,000 μg/kg, and xylenes at 46,000 μg/kg. The pH measurements for pond sediment and water generally indicate neutral to slightly alkaline conditions, with pH measurements for all but one sample ranging from 7.0 to 8.2. One Pond 1 sediment sample was slightly more acidic, with a pH of 6.6 standard units.

2.3.9 2001–2002 Chemical Delineation and Initial Modeling Study

The chemical delineation and initial modeling study further delineated the lateral extent of chemicals in near-surface groundwater at the four source-areas of concern (Tetra Tech, 2002). The investigation included collecting and chemically analyzing shallow soil and groundwater samples from soil borings, installing four groundwater monitoring wells (DMW-1A. DMW-1B, DMW-2A, and DMW-2B), sampling and chemically analyzing groundwater samples from six existing and four new wells, conducting a tidal influence study, and conducting groundwater flow and chemical-transport modeling. Twelve exploratory borings (borings SB-1 through SB-12 were advanced in the area of the TT Median Area soil excavations and along the western edge of Taxiway Tango to inspect the soil for burned material and possible wastes. Visual inspections of soil found no signs of burned material or evidence of waste disposal at these borings.

Samples from soil borings and temporary wells were collected at the following locations:

TT median area:

- soil samples—SB-1 through SB-12; and TT-4
- groundwater samples—TT-1 through TT-10

PHA:

- soil samples—PA-3 and PA-16
- groundwater samples—PA-1 through PA-16; and SB-13

DA:

- soil samples—DA-2 and DA-8
- groundwater samples—DA-1 through DA-14

These sampling locations are shown in Figure 2-9. Well locations are shown in Figure 2-10 (see wells installed in 2002; wells installed in 1995 and 1996 were also sampled). Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, hexavalent chromium, TPH-DRO, and TPH-GRO. Several soil samples were collected for geotechnical analyses.

Generally, trace to low VOC concentrations were detected in the soil samples. The highest VOC concentrations on site were in DA-8 at a depth of 15 feet (361 μ g/kg), and PA-16 at 20 feet deep (329 μ g/kg). The remaining soil samples all had TCE concentrations less than 30 μ g/kg, and most were generally less than 10 μ g/kg. Exploratory soil borings advanced around Taxiway Tango (SB-1 through SB-12) show no signs of burned materials or wastes.

Wells DMW-1A/1B and DMW-2A/2B were installed to characterize the site geology and vertical extent of groundwater impacts in the surficial aquifer. DMW-1A/1B was installed near groundwater sampling location PA-7, where TCE in the upper surficial aquifer was detected at a concentration of 220,000 μ g/L. DMW-2A/2B was installed near groundwater sampling location PA-15, where VC in the upper surficial aquifer was detected at a concentration of 27,000 μ g/L.

The six previously installed wells (MW-1 through MW-6) and the four newly installed wells (DMW-1A, DMW-1B, DMW-2A, and DMW-2B) were sampled in 2002. Groundwater samples were also collected from the 41 temporary well locations listed above. Data collected during the

groundwater investigation indicate that cVOCs (primarily TCE, cis-1,2-DCE, and VC) and metals (primarily cadmium) were in the groundwater above Maryland groundwater standards.

TCE, *cis*-1,2-DCE, VC, and BTEX results for the groundwater samples are shown in Figures 2-11 through 2-14. As shown in Figure 2-11, the maximum groundwater TCE concentrations for each of the study areas were 650 μg/L at MW-3 for the TT Median Area, 220,000 μg/L at PA-7 for the PHA, 130,000 μg/L at DA-7 for the DA, and 12,000 μg/L at well DMW-2A east of Pond 1. The groundwater plume configurations for *cis*-1,2-DCE (Figure 2-12) and VC (Figure 2-13) are similar to TCE (Figure 2-11); however, the maximum *cis*-1,2-DCE concentration (180,000 μg/L at DA-12) was in the southeastern portion of the study site, whereas the maximum VC concentration (27,000 μg/L at PA-15) was east of Pond 1. BTEX (Figure 2-14) were detected primarily at the PHA and DA and, to a lesser extent, east of Taxiway Tango at well DMW-1A and DMW-1B. A chlorobenzene concentration of 50,000 μg/L was detected east of Taxiway Tango at TT-5. The lateral and vertical distributions of chemicals in groundwater were not delineated during this investigation.

The tidal study indicates that groundwater elevations fluctuate up to 0.31 feet due to tidal influences. The numerical groundwater model was constructed, calibrated, and verified as part of the tidal study. The model was used to locate future groundwater monitoring well locations based on groundwater flow-path analyses.

2.3.10 2003–2004 Data-Gap Investigation and Modeling Study

The 2003–2004 data-gap and groundwater-modeling investigation (Tetra Tech, 2004a) aimed to fully delineate and characterize chemical plumes at the site and model groundwater behavior. The investigation included:

- additional groundwater monitoring well installation and sampling
- collecting 11 soil samples from borings for wells DMW-7, DMW-8, and DMW-9 for geotechnical analyses
- testing the aquifer hydraulics of the 28 newly installed wells
- conducting two rounds of quarterly groundwater sampling and chemical analyses, including bio-parameter analyses (September and December 2003)
- modeling groundwater flow and chemical fate and transport

Nine additional multi-level monitoring wells (DMW-3S/I/D through DMW-11S/I), three shallow wells (DMW-1S, DMW-2S, and MW-7), and four temporary wells (TT-11 through TT-14) were installed as part of this study. The locations of these wells are shown in Figure 2-10 (see wells installed in 2003).

Lithologic results for the study show the surficial aquifer is divided into three zones: the upper surficial aquifer, the intermediate surficial aquifer, and the lower surficial aquifer. This study designated the upper surficial aquifer as the portion above an elevation of ⁻15 feet, the intermediate surficial aquifer as the portion between elevations of ⁻15 and ⁻45 feet, and the lower surficial aquifer as the portion below an elevation of ⁻45 feet. Permeability tests indicate that surficial aquifer hydraulic conductivities range from 0.05 ft/day in clayey material at well DMW-3S, to 35.80 ft/day in sandy material at well MW-1.

The results of the groundwater sampling and chemical analyses for the upper, intermediate, and lower surficial aquifer zones are shown in Figures 2-15 through 2-17. The lateral and vertical distributions of chemical concentrations in groundwater indicate three possible source areas at the site, contributing to three primary groundwater plumes:

- Plume 1, originating from the DA
- Plume 2, originating from the PHA and Pond 1 area
- Plume 3, originating from the TT Median Area

As shown in Figures 2-15 through 2-17, PCE, TCE, cis-1,2-DCE, VC, other cVOCs, BTEX, beryllium, cadmium, chromium, lead, nickel, and zinc in groundwater were reported at concentrations exceeding Maryland groundwater standards. The highest concentrations of TCE were reported at:

- DA at MW-5 and DMW-7S (both at $34,000 \mu g/L$)
- northeast of the DA at DMW-5S (estimated concentration of 30,000 μg/L)
- east of Pond 1 at DMW-2A and DMW-3I (29,000 and 23,000 μg/L, respectively)
- TT Median Area at DMW-11S (estimated concentration of 22,000 µg/L)

In the TT Median Area, the TCE concentration at DMW-11S (estimated concentration of $22,000 \mu g/L$) was more than 30 times greater than the previous maximum for this area

(at MW-3: 650 μ g/L) in 2002. However, the TCE concentration at DMW-1B (9,000 μ g/L) was several orders of magnitude less than the TCE maximum concentration for temporary well sample PA-7 (220,000 μ g/L) in 2002.

The distribution of VOCs in groundwater suggests that dechlorination of TCE to *cis*-1,2-DCE and of *cis*-1,2-DCE to VC was occurring. VOCs were found migrating along the downgradient groundwater-flow path from west to east toward Frog Mortar Creek. Although the three plumes originate at the primary source areas, the plumes have co-mingled to form a single contiguous area of groundwater contamination in the eastern portion of the site (wells DMW-3, DMW-4, and DMW-5) approaching Frog Mortar Creek. Site-specific information was used to develop a conceptual model, including regional setting, soil lithology, aquifer characteristics, and historical and current chemical concentration data. Numerical modeling was conducted to predict groundwater flow and chemical migration in the investigation area.

2.3.11 2003–2004 Quarterly Groundwater Monitoring

Quarterly groundwater sampling of the DRA wells was conducted in September and December 2003 and in March, June, September, and December 2004. The September 2003 results are in the *Data-Gap Investigation and Groundwater Modeling Report* (Tetra Tech, 2004a). The results of the remaining quarterly rounds are summarized in five quarterly sampling reports (Tetra Tech, 2004b—e and 2005a).

For the first two rounds, 38 permanent wells and four temporary wells were sampled in each round. The wells sampled include MW-1 through MW-7, DMW-1A/B through DMW-11S/I, and temporary wells TT-11 through TT-14 (see Figure 2-10). The temporary "TT" wells were not sampled after the December 2003 round. The September 2003 "baseline" samples were analyzed for VOCs, SVOCs, pesticides, total metals, and dissolved metals. Subsequent rounds included the VOC and metals analyses, but SVOC samples were collected only for wells where SVOCs had been detected in the prior round.

Pesticides were not analyzed after September 2003 because no pesticides had been detected in the September 2003 round. Analysis for perchlorate was added for wells sampled in September 2004, and for three of the wells sampled in December 2004. Thirteen wells were sampled in each of the September and December 2004 rounds.

During each of the five rounds, several wells were sampled for bio-parameters consisting of nitrate, sulfate, and ferric iron. The 38 permanent wells were purged using dedicated bladder pumps. The four temporary wells (TT-11 through TT-14) were sampled using low-flow peristaltic pumps.

Concentration contour maps for TCE, *cis*-1,2-DCE, and VC in the upper, intermediate, and lower surficial aquifer zones and time-series trends of several wells were generated for the quarterly monitoring reports. The results for the quarterly sampling rounds are generally consistent with the September 2003 "baseline" results. Notable variations include substantial decreases in TCE concentrations at DMW-1B after the first round, and in TCE concentrations (from 60,000 µg/L to 20,000 µg/L at MW-5 from 1996–2002). TCE concentrations at MW-3 also decreased from 1995–2004. Increasing TCE trends were evident at several downgradient perimeter wells (e.g., DMW-2A, DMW-4S, DMW-4D) until December 2003, then showed an upward spike in March 2004 (June 2004 for DMW-4S), with a subsequent return to pre-spike levels.

2.3.12 2005 Groundwater User Survey

A private potable-well survey for the area around MSA (Tetra Tech, 2005b) was conducted in 2005 and repeated in 2010 (Tetra Tech, 2012c). The surveys had the following objectives:

- review relevant records and other documentation regarding historical and current public and private groundwater users in the area
- obtain current aerial photographs of MSA and environs to identify any wells
- evaluate plume migration from the site to the closest potable-well location
- complete a field verification of wells identified in the records review

The survey elements included:

- reviewing MDE and Baltimore County records to identify wells drilled and/or abandoned, to determine current well uses, and to locate well construction information and any groundwater sampling data available
- identifying areas in the survey area with municipal potable-water
- obtaining and reviewing aerial photographs and topographic maps to identify historical and current well locations
- flying over the site to take current aerial photographs of the neighborhoods east of the site

- summarizing pertinent regulations and policies concerning permitting, compliance, and operating requirements for private and public groundwater users in the survey area
- performing field reconnaissance to verify the status of the wells identified in the public records and document searches (specified above), and to locate additional wells that might be in the area. All wells identified in public records were checked in the field; however, wells east of Frog Mortar Creek were the main focus.

No contacts were made with residents or business owners in the survey area regarding the water source (e.g., municipal, private well) they use for drinking or other uses (e.g., irrigation, process water).

Most of the user-survey area residences and businesses around MSA were supplied by Baltimore County public water. Three reservoirs (Loch Raven, Pretty Boy, and Liberty) in the central, northern, and western parts of the county are surface water impoundments for the public water supply. Water from these reservoirs is piped to the City of Baltimore reservoir, which serves the survey area. Only a limited number of private potable wells appear to be in use.

Data from off-site well logs indicates that most wells are screened in the Patapsco Formation. Depths for these wells range from 57 to 140 feet below the ground surface. South of Eastern Boulevard, wells extending into the Patuxent Formation generally range from 176 to 224 feet deep. North of Eastern Boulevard, two wells in the survey area (ranging from 105 to 135 feet deep) are described as being screened in the Patuxent Formation.

Eighty-four wells in the survey area were documented as possibly being in use. The study indicates that most of these wells are likely associated with properties that have been connected to public water, and these wells may no longer exist. Properties that apparently had not been connected to public water, and which have records of wells, are beyond public lines at the ends of roads or peninsulas.

The former well at 3301 Edwards Lane (i.e., the closest well to the site) was no longer used for drinking water since the property was supplied by public water. Other locations in this area, such as the residence at 800 Middle Road, the Brigadoon Marine Facility, and houses on Claire's Lane, likely have water supply wells. Residences to the north, on Bengies Road, Bourque Avenue, Hillpine Road, and Gladway Road, were clearly not supplied by public water. Residences to the west at the end of Punte Road and Weber Avenue are likewise beyond the area

supplied by public water. Most other residences with well records on file, lying east of Frog Mortar Creek and west of Middle River, are likely connected to public water. The survey findings suggest that no potable wells are now in use in the immediate vicinity of the site. The 3301 Edwards Lane well is the closest potable well to the site; however, it is no longer used and has reportedly been abandoned.

The survey area was divided into three regions for field reconnaissance:

- Region 1: Lands east/northeast of the airport and south of Eastern Boulevard—Bowleys Quarters Road extends the full length of the peninsula east of Frog Mortar Creek. Along the peninsula perimeter are smaller peninsulas extending out into the creek. Other than the dense residential development to the east/northeast, this area primarily consists of small houses built on small waterfront lots. At one time, each of these houses appeared to have been supplied by a domestic well. In recent years, virtually all of them appear to have been connected to public water. Thirty-seven potential well locations were retained following the well records review and field reconnaissance. Most of these wells are in areas where water mains are not shown on county key-maps, or where a sizeable property lies at the end of a peninsula or road, beyond the farthest indication of a public water line.
- Region 2: Lands north of Eastern Boulevard—Most of the residences identified as possibly having wells in this region are on sparsely developed single-lane asphalt roads beyond the end of public water supply mains. This area, referred to as Bengies, appears to have been more accessible and more developed in the 1930s. Several plowed fields are evident in historical photographs, and many of the roads that are overgrown and with no outlet were once connected. This is particularly true of Bengies Road, which consists of three distinct pieces of what was once a continuous road.
- Region 3: Lands west/southwest of the airport and south of Eastern Boulevard—This area is characterized primarily by residential development. Dense residential areas are found along the Wilson Point peninsula, west, and southwest of the airport. West of the MSA, between Middle River and Dark Head Creek, an extensive townhouse development dates from about the 1960s. Overall, the remaining land consists of waterfront areas along the west bank of Middle River and various peninsulas surrounded by tributaries of Middle River. In comparison to the waterfront properties east of Frog Mortar Creek, these residential lots are somewhat larger, and development is organized into subdivisions encompassing the entire peninsula. These areas appear to have received access to public water some time ago.

2.2.13 2005 Additional Soil and Sediment Sampling

At the request of MDE, additional soil samples were collected from Taxiway Tango excavations in areas where elevated total chromium (e.g., 9,300 mg/kg) levels were detected in previous soil samples at Excavation 2. Twelve soil samples (six soil samples from one-foot deep, and six samples from four-foot deep) were collected in May 2005 and analyzed for total chromium and

hexavalent chromium (Tetra Tech, 2005c). Four pond sediment samples were also collected from Pond 1 to supplement previous sediment chemical data collected from this area of the site. The pond sediment samples were analyzed for VOCs, SVOCs, metals, PCBs, hexavalent chromium, and simultaneously extracted metals/acid-volatile sulfides. Samples were collected to complete human health and ecological risk assessments for the site. Sampling locations are shown in Figure 2-18.

Relative to total chromium concentrations, hexavalent chromium was detected at low concentrations in six samples, with concentrations ranging from 0.36–1.4 mg/kg. Five of the six hexavalent chromium detections were in the one-foot samples. Three of the sediment samples had low to moderate concentrations of VOCs, SVOCs, metals, and PCBs. TCE was detected at a concentration of 270,000 μ g/kg in EP1-SD5. High concentrations of benzene (215 μ g/kg), toluene (350,000 μ g/kg), ethylbenzene (30,400 μ g/kg), and xylenes (86,500 μ g/kg) were also detected in EP1-SD5. Hexavalent chromium was not detected in any of the pond sediment samples.

2.3.14 2006 Groundwater Monitoring

Groundwater samples were collected from 36 wells in August 2006 to provide current water-quality data for the DRA. Wells sampled include MW-2 through MW-6, DMW-1A/B through DMW-11S/I (see Figure 2-10). The temporary "TT" wells were not sampled in 2006. Samples were analyzed for VOC, 1,4-dioxane, perchlorate, total and dissolved metals, and hexavalent chromium. Additionally, DMW-3S and DMW-9S were analyzed for SVOCs.

Sampling results indicate that cVOC concentrations exceed Maryland groundwater standards throughout a large portion of the investigation area at multiple depths. The maximum TCE concentration observed in a 2006 monitoring well sample was 41,000 µg/L reported for upper surficial-aquifer well DMW-11S. 1,4-Dioxane and perchlorate were detected in 34 and 17 groundwater samples, respectively. Hexavalent chromium was not detected in these samples. Low concentrations of several SVOCs were detected at DMW-3S and DMW-9S. The results were not presented in a report.

2.3.15 2007–2008 Additional On-Site Soil and Groundwater Characterization

To further delineate and characterize the chemical plumes and provide data to support evaluation of remedial alternatives, additional on-site soil and groundwater characterizations were conducted from September 2007 through February 2008 (Tetra Tech, 2008). The overall objectives of the field activities were to characterize the subsurface soil in the vadose and saturated zones, delineate the lateral boundaries of the contamination in soil and groundwater, and delineate the vertical extent of contamination in soil and groundwater. The study included EM and gamma geophysical surveys to identify anomalies in the subsurface that may represent buried waste and possible contaminant source(s).

Twenty-five test pits (test pits A1 through A17 and N1 through N8) were excavated at locations identified by the geophysical survey as being either anomalous or non-anomalous to provide depth of fill data, visual identification of buried debris, and soil samples for laboratory analysis (Figure 2-20). Test pits designated with an "A" were in areas identified as having a geophysical survey anomaly (i.e., an area of elevated electromagnetic conductance), whereas the "N"-designated tests pits were in areas where geophysical anomalies were not observed (i.e., "non-anomalous" areas).

Fifty soil samples were collected from these test pits based on field observations. Thirty-four soil samples were collected from anomalous (A) test pits, and 16 soil samples were collected from non-anomalous (N) test pits. Most of these samples were collected from the test pit areas that displayed fill material with debris, stains, and/or leachates during visual field observations.

The field program also advanced 52 membrane interface probes (MIP)/cone penetration tests (CPT), and installed 12 new, multi-level (nested) surficial aquifer wells, followed by groundwater sampling. MIP/CPT screening provided a vertical profile of electrical conductivity and VOCs in subsurface soils and groundwater and identified the areas/sources of contamination to collect DPT soil and groundwater samples from and locate monitoring wells in. The MIP/CPT investigation installed 31 monitoring wells, including shallow, intermediate, and deep monitoring wells MW-14I/D through MW-26S/I/D.

The "S" well screens were installed to a depth of approximately 30 feet and the "I" and "D" well screens were installed to approximate depths of 50 and 80 feet, respectively. In addition, two

shallow and two intermediate wells were installed as pumping-test and observation wells (OW-1S/I and RW-1I/S) to support aquifer hydraulics testing. Well locations are shown in Figure 2-19 (see wells installed 2007–2008). The existing and newly installed nested wells were sampled for target contaminant analyses.

As shown in Figure 2-20, the geophysical investigation showed suspected waste (i.e., metal containing materials) present over approximately 19 acres at the site. When areas inaccessible to the investigation but suspected of containing waste (the areas of Ponds 1 and 2 and east of the ponds) are included, the total impact area was estimated at approximately 25 acres. The investigation appears to have delineated the extent of the waste in all directions.

The surficial-gamma survey results showed an average background reading of 6,600 counts per minute (cpm). Two areas showed significant positive deviation from that average, although the count rates were not high. These areas were investigated via test pits to confirm the geophysical investigation findings, and these locations were found to contain clay rich soils in the subsurface, the likely source of the elevated gamma survey results.

Observation of the test pit excavations showed that, with few exceptions, most "A" pits showed signs of metallic and land fill materials, whereas the "N" pits were mostly clear. The debris and buried materials found at all pits included various metallic objects (i.e., pipes, wires, fences, concrete rebar, scraps, paint cans, and rusty, charred 55-gallon drums), glass bottles, wood, fiberglass, plastics, small batteries, concrete blocks, and rubble. In addition, stained or sludge-like sediment/soil, strong odors, and seepage water with a black or slightly reflective sheen were noted in several test pits. Anomalies were detected and evidence of debris and landfilling activity was observed in the following test pits: A4, A5, A6, A10, A11, A12, A14, A15, A17, N4, and N8 (see Figure 2-20).

To benchmark any exceedances, the analytical data results from the test-pit soil samples were compared against MDE residential and non-residential soil standards (MDE, 2008). VOC concentrations were low, with no exceedances of MDE soil standards for any test-pit soil samples. TCE was detected in 41 samples at trace to low concentrations ranging from 1.0 to 9.9 μg/kg. The maximum TCE concentration was detected east of Pond 1 at sampling location N5-0304. VC and *cis*-1,2-DCE were similarly detected in test-pit soil samples at low concentrations, with *cis*-1,2-DCE concentrations in 22 samples ranging from 0.61 to 81.8 μg/kg

(maximum at sampling location A5-0809), and VC concentrations in 17 samples ranging from 0.66 to 96.1 μ g/kg (maximum at sampling location A1-0910). PCE was detected in four samples at concentrations ranging from 0.71 to 3.6 μ g/kg.

BTEX was also detected in soil at low concentrations in 14 (xylenes) to 35 (toluene) samples. BTEX concentrations were higher than those detected for cVOCs, with the maximum concentrations of benzene (115 μ g/kg), toluene (3,370 μ g/kg), ethylbenzene (6,090 μ g/kg), and xylenes (284 μ g/kg) all above 96.1 μ g/kg (maximum VC concentration at sampling location A1-0910). The maximum concentrations of benzene, ethylbenzene, and xylenes were detected west of the PHA and east of Taxiway Tango, in sampling location A1-0910. The maximum concentrations of toluene and naphthalene (2,750 μ g/kg) were detected east of Pond 2, in sampling location A16-0910.

The MIP investigation found elevated electron-capture device (ECD) responses indicating cVOCs at 19 of the 52 tested locations in 2007 (see locations 1–52 in Figure 2-21). The cVOC impacts observed using the MIPs testing appear to be bounded north, south, and west of the study area. Significant ECD readings in shallow vadose-zone soil were observed at only two locations (MIP-57 and MIP-58) between Taxiway Tango and the runway.

The 25 soil and 20 groundwater samples collected from DPT locations confirmed cVOCs in the borings exhibiting elevated ECD responses. As shown in Figure 2-22, the maximum TCE concentration in soil was 7,680 μg/kg (MIP-58 at 10 feet below grade); however, limited exceedances of MDE residential-soil standards were observed. As shown in Figure 2-23, the maximum concentration of primary cVOCs (TCE, *cis*-1,2-DCE, and VC) in groundwater was 78,530 μg/L (TCE only was 68,600 μg/L) at MIP-28 at 34–36 feet below grade; this concentration and those detected at multiple other borings exceed groundwater standards. Petroleum hydrocarbons were also detected in these samples but are not shown in the figure.

Sampling of groundwater monitoring wells confirmed cVOCs and pVOCs, metals, and 1,4-dioxane throughout a large portion of the investigation area, at multiple depths, and at high concentrations. The maximum TCE concentration $(41,400 \,\mu\text{g/L})$ was observed in well DMW-11I. The TCE-impacted area extends north to a section north of Pond 2, south to DMW-7I, and west to the area between Taxiway Tango and the runway. The maximum 1,4-dioxane concentration observed in a monitoring well sample was 1,800 $\mu\text{g/L}$ (DMW-3S).

The substantial impact from 1,4-dioxane appears isolated to the central portion of the site, extending north to MW-18, south to DMW-7, and west to DMW-9. The maximum perchlorate concentration observed in a monitoring well sample was 8 µg/L (DMW-7I). Perchlorate impacts in groundwater are generally confined to the area southeast of Pond 2. However, new monitoring wells were not analyzed for perchlorate. A wide range of metals exceeded MDE groundwater standards at locations throughout the site. Exceedances were observed for arsenic, barium, beryllium, cadmium, chromium, lead, nickel, selenium, vanadium, and zinc.

2.3.16 2008 Groundwater Monitoring

Groundwater samples were collected in August–September 2008 at 69 existing and newly installed monitoring wells to provide an additional annual set of groundwater chemical data for the site (Tetra Tech, 2009b). Sampling results indicated that concentrations of cVOCs exceed Maryland groundwater standards throughout a large portion of the investigation area, and at multiple depths. The maximum TCE concentration observed in a 2008 monitoring well sample was 29,000 µg/L, reported for upper surficial-aquifer well DMW-11S. Multiple VOC sources at the site and groundwater flow conditions have produced VOC-impacted groundwater extending to areas north of Pond 2, south to DMW-6I and DMW-7I and west to the area between Taxiway Tango and the runway. cVOCs were detected at concentrations exceeding Maryland groundwater standards in samples from monitoring wells recently installed north and east of Pond 2 and south of pre-existing wells.

Concentrations of cVOCs in groundwater decreased substantially as compared to the 2004 analytical results for these chemicals. The reduction in TCE concentrations in 2008, and the high concentrations of chemical daughter products such as *cis*-1,2-DCE and VC indicated that TCE degradation was occurring at the site. Concentrations of 12 metals exceeded groundwater standards in one or more groundwater samples. VOC contamination has not been fully delineated north–northwest of well clusters MW-14, MW-17, and MW-28; east of well clusters MW-14, MW-18, DMW-3, DMW-2, DMW-4, and DMW-5; west of DMW-11S; and south of well clusters MW-19 and MW-24.

The SVOC 1,4-dioxane was detected primarily in groundwater samples collected from the upper and intermediate surficial-aquifer zones. 1,4-Dioxane was co-located in areas containing the highest cVOC concentrations, and occurred primarily near Pond 1 and the area east of Pond 1.

The highest concentrations of 1,4-dioxane were 590 μ g/L at well MW-16S, northwest of Pond 2, and 490 μ g/L at well DMW-2A, east of Pond 1 near Frog Mortar Creek.

2.3.17 2008–2009 Deep-Groundwater Investigation

Previous groundwater sampling results indicate TCE at the base of the lower surficial aquifer, at concentrations ranging from 2,400 to 4,400 μ g/L. At these concentrations, residual TCE-product, or dense non-aqueous phase liquids (DNAPLs), may be in the lower surficial aquifer and may be transported downward via gravity, or as dissolved constituents in groundwater in response to downward, vertical, hydraulic gradients.

In 2008, four deep wells (MW-27D and MW-29D through MW-31D: see Figure 2-19) were installed to 165 to 207 feet below grade to determine the thickness and extent of the clay underlying the lower surficial aquifer, and to determine if TCE had migrated below the lower surficial aquifer (Tetra Tech, 2009a). A fifth boring, for an intermediate surficial-aquifer well, (MW-28I) was advanced 50 feet deep (see Figure 2-19). cVOCs, VOC-degradation products, and the SVOC 1,4-dioxane (detected in lower surficial-aquifer groundwater) were not detected in the deep-well groundwater samples. A few petroleum-related VOCs and SVOCs were detected in the deep groundwater samples at concentrations below MCLs. However, the VOCs and SVOCs detected are common laboratory contaminants and may have been artifacts of the laboratory analyses.

2.3.18 2009 Groundwater Monitoring

In August through September 2009, groundwater samples were collected from six newly installed wells (wells MW-32S, MW-32I, MW-33S, MW-33I, MW-34S, and MW-34I) and 59 existing wells to provide a current annual round of groundwater data (Tetra Tech, 2010a). The wells installed in 2007–2008, and before 2008, are shown in Figure 2-19. These data describe then-current groundwater quality conditions at the facility, to evaluate temporal trends of groundwater contaminants, and to evaluate remedial actions in subsequent studies. Groundwater samples were chemically analyzed for VOCs, 1,4-dioxane, perchlorate, metals, TPH-DRO, TPH-GRO, and several water quality indicators. Samples from the six newly installed wells were also analyzed for SVOCs. Groundwater levels were also measured to provide data for groundwater contour maps.

The following summarizes the findings of the 2009 groundwater sampling and analyses:

- Groundwater flow in the upper, intermediate, and lower surficial-aquifer zones is generally northeast toward Frog Mortar Creek. However, local variations in the hydrology of the upper, intermediate, and lower surficial aquifer zones provide divergent flow locally at the center of the site, and flow toward the south at the southern end of the site.
- Concentrations of cVOCs exceed Maryland groundwater standards throughout a large portion of the investigation area, and at multiple depths. The maximum TCE concentration for the round was 36,000 µg/L, reported for upper surficial aquifer well DMW-11S, in the TT Median Area. Multiple VOC sources at the site have resulted in VOC-impacted groundwater extending to areas north of Pond 2, south to DMW-6I and DMW-7I, and west to the area between Taxiway Tango and the runway.
- cVOCs were detected at concentrations exceeding Maryland groundwater standards in samples from monitoring wells that had recently been installed northwest of Pond 2. TCE was not detected in two new wells installed south of the DA plume MW-32S and MW-32I).
- Concentrations of cVOCs in groundwater are consistent with the 2008 results, and generally decreased substantially as compared to the 2004 chemical results.
- At six wells where groundwater samples were analyzed for natural-attenuation parameters, anaerobic reductive-dechlorination was evidenced by the TCE-breakdown products *cis*-1,2-DCE, *trans*-1,2-dichloroethene, and 1,1-dichloroethene. The presence of VC, ethane, and elevated chloride concentrations indicate that complete dechlorination may be occurring in the upper and intermediate surficial aquifer. However, the absence of detectable concentrations of VC, low concentrations of ethane and iron, a low groundwater pH, a high nitrate concentration, and a high oxidation-reduction potential indicate that slow or incomplete reductive dechlorination of lower-order cVOCs may be occurring in the lower surficial aquifer.
- VOC groundwater contamination was found at concentrations greater than groundwater standards at the current site boundaries to the north (wells MW-14I, MW-15S/I, MW-16S/I, MW-17I, and MW-28I), east (wells MW-14I, MW-18I/S, DMW-3S/I, DMW-4S/I/D, and DMW-5S/I), and west (wells MW-24I, DMW-11S, and MW-33S). Additional wells and groundwater sampling were recommended beyond the current site boundaries in these areas to define the VOC plume boundaries by concentrations less than the groundwater standards.
- Sampling results for wells DMW-6I/D and MW-32S/I indicate that the VOC groundwater-contamination is bounded along the southern portion of the site.
- The SVOC 1,4-dioxane was primarily detected in groundwater samples collected from the upper and intermediate surficial aquifer. 1,4-Dioxane is co-located in areas containing the highest concentrations of cVOCs, occurring primarily near Pond 1 and the area to the east. The highest concentrations of 1,4-dioxane were 1,100 μg/L at well DMW-3I east of Pond 1 near Frog Mortar Creek, and 790 μg/L at well MW-16S north of Pond 2.

- TPH-DRO was detected in more than half (57%) of the 2009 groundwater samples, at concentrations ranging from 150–1,300 μg/L (averaging 508 μg/L). TPH-GRO was detected in nearly all (96%) of the 2009 groundwater samples at concentrations ranging from 30–70,000 μg/L (averaging 4,425 μg/L). Most DRO and GRO concentrations exceeded the MDE criterion of 47 μg/L. The greatest concentrations were detected in wells DMW-20S (TPH-DRO) and DMW-9S (TPH-GRO) in the PHA near Pond 1. Substantially lower concentrations of TPH-DRO and TPH-GRO were reported for wells in the DA and TT Median.
- Perchlorate was detected in several groundwater samples at low concentrations not exceeding the Maryland groundwater standard. Two samples from DMW-4I and DMW-4D had concentrations exceeding the Maryland groundwater standard. These wells are east of Pond 1. During the 2007 sampling, three wells (DMW-4S, DMW-7I, and DMW-8S) had concentrations of perchlorate exceeding the Maryland groundwater criterion. Wells DMW-7I and DMW-8S are west–southwest of and near well cluster DMW-4S/I. Samples for perchlorate analysis were not collected in 2008.
- Concentrations of 11 metals exceeded the groundwater standards in one or more groundwater samples. Concentrations of manganese and iron exceed the standards most frequently, with the maximum concentrations exceeding the standards by more than a factor of 100. Concentrations of cadmium exceed the standard in nearly 20% of samples, with the maximum concentration exceeding the groundwater standard by more than two orders of magnitude. Concentrations of other metals (chromium, lead, mercury, and selenium) exceed standards in less than 10% of samples, ranging from one exceedance for selenium to three for lead. Dissolved lead and mercury concentrations did not exceed standards.

2.3.19 2009 Remedial Investigation

Environmental and engineering data collected from 2000–2009 were evaluated together to describe and characterize the extent of soil, groundwater, and pond-sediment chemical contamination at the DRA. A detailed human health risk assessment (HHRA) and an ecological risk assessment (ERA) were conducted using the prior data to evaluate potential human health risks and potential risks to ecological receptors. The HHRA was updated in early 2012 (Tetra Tech, 2012a).

The RI evaluates previous geophysical surveys, test pits, soil borings, and soil sample chemical analyses to identify surface and subsurface soil contamination from buried fill material. These investigations identified approximately 25 acres of soil fill and debris beneath Taxiway Tango, extending east to the base of the embankment at Frog Mortar Creek. The fill material consists of up to 11 feet of soil, stained soil, and solid waste, the latter of which is comprised of concrete rubble and disposed industrial items such as batteries, decomposed drums, tires, paint cans, burnt

items, sludge, buckets, glass, wood, etc. Four inert bombs were also uncovered in 2000 at TT Median Area Excavation 5 and removed from MSA. As described previously, soil borings up to 268 feet below grade have been advanced at the site to determine the hydrogeologic framework of the site, and to install groundwater monitoring wells.

Chemical analyses of numerous surface and subsurface soil samples indicate VOCs, SVOCs, PCBs, and several metals in soil at concentrations exceeding United States Environmental Protection Agency (USEPA) human health and ecological risk-based screening levels and MDE soil cleanup standards. The primary VOCs detected in soil samples were TCE, TCE-degradation products such as *cis*-1,2-DCE and VC, and BTEX. TCE is a chlorinated solvent used in industry to clean machinery and parts, and BTEX are volatile constituents of petroleum based fuels and lubricating oils. SVOCs detected in soil include polycyclic aromatic hydrocarbons (PAHs), which are a group of compounds derived from the combustion of materials. A subset of the 20 metals detected in soil at the site includes antimony, arsenic, cadmium, copper, total and hexavalent chromium, lead, mercury, nickel, and zinc.

Past dumping and backfilling have produced large contaminant plumes of VOCs and more limited plumes of SVOCs and metals in groundwater in the upper, intermediate, and lower portions of the surficial aquifer west of Taxiway Tango and extending to Frog Mortar Creek. The VOC plumes extend to an area more than 1,000 feet wide and 1,400 feet long (more than 30 acres) and up to 80 feet below grade. Concentrations of VOCs, SVOCs, and several metals exceeded drinking water and groundwater standards.

The primary VOCs detected in groundwater were TCE, *cis*-1,2-DCE, VC, and BTEX. The SVOC detected most frequently in groundwater at levels exceeding its groundwater screening-criterion was 1,4-dioxane. Metals found at concentrations exceeding groundwater standards in 10% or more of samples were arsenic, beryllium, cadmium, iron, manganese, nickel, and vanadium. Concentrations of manganese and iron exceeded groundwater standards most frequently, at rates of 81% (iron) to 90% (manganese) of samples.

Chemical analyses of pond sediment samples indicated VOCs, SVOCs, PCBs, and several metals at concentrations exceeding USEPA human health and ecological risk-based screening levels and MDE soil cleanup standards. The primary VOCs detected in pond sediment samples were TCE, TCE-degradation products such as *cis*-1,2-DCE and VC, and BTEX. TCE was

detected in four sediment samples in Pond 1 at high concentrations (3,300 μ g/kg to 270,000 μ g/kg). These concentrations indicate residual TCE product or DNAPL in Pond 1 sediment. BTEX was also detected in Pond 1 sediment samples at high concentrations (411,000 μ g/kg to 467,115 μ g/kg). Pond 1 is therefore considered a possible source of groundwater VOC contamination.

SVOCs detected in sediment included PAHs. Metals detected in pond sediment included arsenic, beryllium, cadmium, total chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. However, only arsenic, cadmium, total chromium, and hexavalent chromium were selected as metal chemicals of potential concern (COPC) in pond sediment. PCBs were detected, but their concentrations did not exceed its screening criterion. Concentrations of VOCs, SVOCs, metals, and associated exceedances of screening criteria for sediments are limited to the Pond 1 sediment samples. One metal (zinc) was detected in one of two pond water samples. No human health COPC were selected in the risk assessment based on surface water sampling results.

An HHRA evaluated risk to potential human receptors under current and likely future land uses, in accordance with USEPA and MDE guidelines. The HHRA considered receptor exposure under non-residential (e.g., industrial, recreational) land use scenarios. Although the site is not expected to be used for residential purposes in the foreseeable future, residential land uses were also evaluated. The HHRA also developed preliminary cleanup goals for environmental media and contaminants significantly contributing to the cancer risk and/or hazard index for each exposure pathway in a land use scenario for a given receptor group.

The predominant human health COPC for direct-contact exposure were cVOCs in soils, groundwater, and sediments; BTEX in soils and groundwater; substituted benzene compounds in soils and groundwater; PAHs in soils and sediments; and several metals in soil and groundwater (e.g., arsenic, cadmium, lead, copper, total and hexavalent chromium, nickel). Hexavalent chromium was detected in fewer than 50% of surface soil samples analyzed, in only one of 18 subsurface soil samples, and in three of four pond-sediment samples. Additionally, concentrations detected in surface soils indicate that hexavalent chromium is not the predominant chromium species in site soils (a comparison of hexavalent chromium concentrations to total chromium concentrations indicates that only 1.5 to 4.4% of total chromium is in the hexavalent

state). Hexavalent chromium was selected as a COPC for soil and sediment. The quantitative risk evaluation conservatively assumes that 1% of total chromium in soil and sediment is present as hexavalent chromium.

Direct ingestion of groundwater at the DRA is expected to be limited to exposures that would occur under a future residential scenario. Construction workers would likely be exposed to groundwater during construction/excavation activities via dermal contact, incidental ingestion, or via inhalation of volatiles in the groundwater. Industrial workers would not be expected to encounter groundwater, as it is not currently used as a source of potable or industrial water at the site, nor is such use likely in the future. The groundwater user survey also indicated the possibility of wells near MSA, but these wells, if they exist, would be upgradient of MSA, or have been reported abandoned and no longer used.

Trespassers/visitors could incidentally ingest surface water while on site. However, only one surface water chemical, zinc, was detected, and no COPC had been selected for surface water. Therefore, risks associated with trespasser exposures to surface water were not quantitatively evaluated in this HHRA. The predominant COPC for the vapor-intrusion pathway were TCE, VC, and *cis*-1,2-DCE. Many of these organic and inorganic chemicals were also selected as COPC to evaluate chemical migration from soils to groundwater.

The ERA was conducted in accordance with USEPA guidelines to evaluate risk to potential ecological receptors in surface soil, sediment, and groundwater (evaluated as surface water). The central area of the site northwest of Pond 1 appears to be the area of largest ecological risk, based on current sampling data. Surface soil ecological COPC for invertebrates and plants include TCE, *cis*-1,2-DCE, antimony, chromium, copper, manganese, molybdenum, and zinc. PAHs were COPC only for soil invertebrates, whereas cadmium, lead, nickel, and selenium were retained as COPC only for plants. VOCs, PAHs, PCBs, and several metals were retained as COPC for Pond 1 sediment. For groundwater evaluated as surface water, several VOCs and metals exceeded surface water criteria, even after a dilution factor as high as 50-fold was applied to chemical concentrations. Further evaluation of surface soil, using less conservative exposure assumptions, identified several metals (mercury, cadmium, lead, and molybdenum) as risks to wildlife (e.g., quails, shrews, robins).

2.3.20 2010 Off-Site Piezometer Installation and Water Level Monitoring

In March 2010, six off-site piezometers (PZ-1S/I/D and PZ-2S/I/D) were installed on two privately owned properties (3300 and 3301 Edwards Lane) on a peninsula of Bowleys Quarters, east of the DRA on the eastern shoreline of Frog Mortar Creek (Tetra Tech, 2010b). The locations of the piezometers are shown in Figure 2-19. Groundwater levels in the six piezometers and three DRA wells, and creek levels in Frog Mortar Creek, were monitored and recorded for one month. These data were used to better understand off-site groundwater characteristics, including the extent to which the surficial aquifer at the monitoring points is tidally influenced, the presence of vertical hydraulic gradients, and their relationship to DRA groundwater characteristics. These data were also used to model DRA groundwater.

The piezometers were screened at depths of approximately five to 15 feet (shallow zone), 29 to 39 feet (intermediate zone) and 42 to 52 or 46 to 56 feet (deep zone) below grade. Screened intervals for the piezometers were set at elevations nearly equivalent to wells installed in the eastern portion of the DRA. The six newly installed piezometers and three DRA wells and DMW-4D) were with (DMW-4S, DMW-4I, fitted electronic water-level data-loggers/pressure transducers to record water-level data. A data logger was also placed in a locked perforated-steel standpipe installed at 3300 and 3301 Edwards Lane to record creek levels during the same period as the piezometers and DRA wells. A data logger that records atmospheric barometric pressure was also installed in well DMW-8S at the DRA site to record barometric pressure fluctuations during the monitoring period.

Groundwater levels, surface water levels, and barometric pressure were recorded for one month from June 2–July 6, 2010. Water levels in wells DMW-3S/I/D, the off-site piezometers, and Frog Mortar Creek were also collected for 30 days from March to April 2011 (Tetra Tech, 2011b). These studies indicate that groundwater levels in the surficial aquifer are influenced by both tides and barometric pressure.

2.3.21 2010 Groundwater Monitoring

Groundwater and Frog Mortar Creek surface water were sampled in July 2010 to provide additional rounds of groundwater and surface water quality data (Tetra Tech, 2010c). Groundwater samples were collected from six wells installed in 2009 (wells MW-32S, MW-32I, MW-33S. MW-33I, MW-34S, and MW-34I) and 59 wells installed before 2009. These

monitoring wells are shown in Figure 2-19. Groundwater levels in wells were also measured to provide data for groundwater contour maps.

Groundwater and surface water samples were chemically analyzed for VOCs, 1,4-dioxane, metals, perchlorate (a propellant constituent), and field water quality indicators. Groundwater samples were also analyzed for TPH-DRO, TPH-GRO, cyclotrimethylene-trinitramine (also known as Royal Demolition Explosive [RDX]), radium-226, radium-228, and natural-attenuation assessment (NAA) parameters. The following summarizes the findings of the groundwater and surface water sampling and analyses:

- Groundwater in the upper, intermediate, and lower surficial aquifer zones flows northeast, to Frog Mortar Creek.
- Concentrations of cVOCs exceed Maryland groundwater standards throughout a large portion of the investigation area and at multiple depths. The maximum TCE concentration observed in a monitoring well sample is 36,000 µg/L, reported for upper surficial aquifer well DMW-11S.
- Generally, concentrations of cVOCs in groundwater were consistent with the 2009 results. Time-series plots of VOCs in source areas and downgradient locations indicate a general decrease in VOC concentrations since monitoring in the early 2000s. However, VOC concentrations in the source area for the TT Median Area plume (DMW-11S) have remained steady or increased slightly since 2003.
- At six wells where groundwater samples were analyzed for NAA parameters, anaerobic reductive-dechlorination is evidenced by the TCE-breakdown product *cis*-1,2-DCE. The presence of VC, methane, ethene, and elevated chloride concentrations indicates that complete dechlorination may be readily occurring in the upper and intermediate surficial aquifer zones. However, lower relative concentrations of VC, methane, ethene, low groundwater pH, and high oxidation-reduction potential indicate that slow or incomplete reductive dechlorination of lower-order cVOCs may be occurring in the lower surficial aquifer zone.
- cVOCs were at concentrations greater than groundwater standards at perimeter wells to the north (wells MW-14I, MW-15S/I, MW-16S/I, MW-17I, and MW-28I), east (wells MW-14I, MW-18I/S, DMW-3S/I, DMW-4S/I/D, and DMW-5S/I), and west (wells MW-24I, DMW-11S, and MW-33S).
- Sampling results for wells DMW-6I/D and MW-32S/I indicate that the VOC groundwater contamination is bounded along the southern portion of the site.
- The SVOC 1,4-dioxane was detected primarily in groundwater samples from the upper and intermediate surficial aquifer zones. 1,4-Dioxane was co-located in areas containing the highest concentrations of cVOCs, primarily near Pond 1 and the area to the east. The

highest concentrations of 1,4-dioxane were east of Pond 1 near Frog Mortar Creek at wells DMW-2A (590 μ g/L), DMW-3S (480 μ g/L), and DMW-3I (390 μ g/L). 1,4-Dioxane was detected at a concentration of 1.8 μ g/L at Frog Mortar Creek surface water sampling location SW38, nearest the DRA; however, this concentration is less than the human health screening criteria and state advisories/standards for drinking water.

- TPH-DRO was detected in 70% of the 2010 upper surficial aquifer groundwater samples, at concentrations ranging from 78–2,000 μg/L (averaging 473 μg/L). TPH-GRO was detected in slightly more than half (59%) of the 2010 upper surficial aquifer groundwater samples, at concentrations ranging from 34–55,000 μg/L (averaging 4,349 μg/L). Most DRO and GRO concentrations exceed the MDE criterion of 47 μg/L. The greatest concentrations of DRO and GRO were detected in well DMW-9S, in the PHA and Pond 1 Area. Substantially lower concentrations of TPH-DRO and TPH-GRO were reported for groundwater in the DA and TT Median Area.
- Perchlorate and the explosive RDX were not detected in the DRA groundwater samples.
- Concentrations of 11 metals exceeded groundwater standards in one or more groundwater samples. Concentrations of iron and manganese exceeded standards most frequently, with the maximum concentrations of these two metals exceeding standards by more than a factor of 100. Concentrations of cadmium exceed the standard in nearly 20% of the samples, with the maximum concentration of 833 µg/L exceeding the groundwater standard by more than two orders of magnitude. Arsenic, beryllium, nickel, and vanadium concentrations also exceed standards. However, the maximum concentration of vanadium is less than two orders of magnitude than the groundwater standard, and the maximum levels of arsenic and nickel are less than 10 times the standards. Concentrations of metals (such as chromium, lead, mercury, and selenium) exceeded standards in less than 10% of samples, ranging from four exceedances for chromium to one exceedance each for selenium and mercury. Dissolved lead and mercury concentrations (i.e., for filtered samples) did not exceed standards.
- Radium-228 and combined radium-226/228 concentrations exceeded the groundwater standard in samples at intermediate and deep surficial-aquifer wells. Radium-228 concentrations exceeded the groundwater standard of 5 picoCuries per liter (pCi/L) in samples from wells DMW-3I (7.53 pCi/L), DMW-6I (11.6 pCi/L), and DMW-6D (7.82 pCi/L). The combined radium-226/228 concentration in the sample from well DMW-3D (6.30 pCi/L) also exceeded the groundwater standard. Combined radium-226/228 concentrations for wells DMW-3I, DMW-6I, and DMW-6D that exceeded the groundwater standard are 8.264, 12.046, and 9.53 pCi/L, respectively. Concentrations of radium-226, radium-228, or combined radium-226/228 did not exceed the groundwater standard in samples collected from the upper surficial aquifer (MW-3, DMW-6S, DMW-16S), deep confined aquifer (MW-27D, and MW-29D), or the third well sampled in the intermediate surficial aquifer (MW-16I).
- The primary VOC groundwater-contaminants TCE, cis-1,2-DCE, VC, and 1,4-dioxane were detected in Frog Mortar Creek surface sampling location SW38, along the Frog Mortar Creek shoreline northeast of the DRA VOC plumes. The results indicate that VOC-contaminated groundwater from the DRA was discharging to Frog Mortar Creek.

2.3.22 2010 Supplemental Design Characterization Investigation

A supplemental investigation of the DRA was conducted in 2010 to fill data gaps and provide additional information to complete a remedial design (Tetra Tech, 2011a). The source of VOCs in the DMW-11S area had not been fully characterized or delineated before this investigation. Well DMW-11S historically contained the highest concentrations of VOCs in groundwater at the DRA (TCE concentrations greater than 30,000 µg/L), and was considered one of the VOC source areas at the site. TCE and other VOCs have not been delineated north and west of well MW-33S/I, where concentrations of TCE and TCE-degradation products exceeded Maryland groundwater standards. Supplemental activities included topographic mapping, wetland identification and mapping, passive soil-gas sampling and analysis, synoptic and long-term groundwater level monitoring, aquifer-hydraulics testing, groundwater modeling, and geophysical surveying. Results of the long-term groundwater monitoring and groundwater modeling update are in documents separate from the supplemental report.

The topographical survey area spanned southeast of Taxiway Tango to the MDANG Jet Engine Test Pad, and from the eastern side of Taxiway Tango to the western shoreline of Frog Mortar Creek. The survey shows that site topography ranges from flat to gently sloping to the northeast toward Frog Mortar Creek. In the northern portion of the DRA, land elevations range from approximately 11 feet above North American Vertical Datum of 1988 (NAVD88) near the runway to approximately seven feet above NAVD88 at Pond 2.

Land elevations are approximately 20 feet above NAVD88 at a mounded area near the embankment of Frog Mortar Creek in the southeastern portion of the site. The steep embankment, comprised of fill placed there as part of airport construction, runs along the Frog Mortar Creek shoreline and through the northern edge of the wetlands. The topography is flat to gently sloping near a large lobate region between the wetlands and the DRA. A wetlands delineation survey was conducted in the same area as the topographic survey. The survey results were used to evaluate the potential reduction or increase in wetland functions and values associated with any remediation project, as well as the value of any wetland functions that may need to be replaced for compensatory mitigation.

A passive soil-gas survey to evaluate VOCs in soil was conducted near Taxiway Tango and the airport runway, where access for soil borings and well installations is limited. One hundred and

one GORE Sorber[™] passive soil-gas samplers were installed four feet below grade near Taxiway Tango and the airport runway, as well as at locations northwest, west, and southwest of wells DMW-11S and MW-33S. Of the 99 passive soil-gas samples analyzed for VOCs, TPH, and diesel alkanes (two sorbers were damaged by animals), the maximum soil-gas masses of TCE (51.51 μg) and *cis*-1,2-DCE (73.12 μg) were reported approximately 180 feet northwest of well MW-33S. Relatively low masses of TCE ranging from 0.03–0.10 μg were detected on the western side of Taxiway Tango.

Similar to the cVOCs, the highest levels of BTEX, naphthalene, 2-methylnaphthalene, and TPH were found west and northwest of MW-33S, with lower masses in the area on the western side of Taxiway Tango. These results indicate a contamination source of either a weathered gasoline or a heavier petroleum product, such as diesel or jet fuel. Despite the low relative masses of diesel-range alkanes in the passive samples, a diesel/jet fuel source cannot be ruled out due to the presence of diesel-range organics at MW-33S. The VOC source area was readily determined from the soil-gas results.

Supplemental study activities also included a round of measured synoptic groundwater levels at the DRA monitoring wells. These data were used to construct groundwater-elevation contour maps. The results of the water-level study indicate that groundwater flows northeast toward Frog Mortar Creek in the upper, intermediate, and lower surficial aquifer zones, and northwest to southeast in the deep confined aquifer.

Slug tests were conducted on 17 wells (16 surficial aquifer wells and one deep confined aquifer well) in the DRA. Slug test analyses indicate hydraulic conductivities for the lower surficial-aquifer wells ranging from 2.74 ft/day at MW-18D to 25.5 ft/day at MW-15D with a geometric mean (excluding MW-17D and MW-26D, which are both set in relatively clayey lithology) of 8.4 ft/day (arithmetic mean of 11.3 ft/day). The 2003 and 2010 slug test results for wells DMW-7I and DMW-8D indicate comparable results (i.e., same order of magnitude estimates) for both the solid-slug and pneumatic-slug test methods.

The MSA groundwater modeling study addressed the development, calibration, and application of a groundwater flow model to develop remediation alternatives for addressing VOCs and 1,4-dioxane contamination in groundwater at DRA. The remediation alternatives were based on the primary objectives of controlling and capturing contaminated groundwater to prevent its

migration into off-site areas and toward Frog Mortar Creek. The model results indicate that the simulated hydraulic-barrier wells form an effective hydraulic barrier for upgradient and contaminated groundwater, without inducing significant inflow of higher salinity water from Frog Mortar Creek into the aquifer. In the remedial scenario simulations, the model predicts that only a very small percentage of extracted groundwater would originate from Frog Mortar Creek, and thus its salinity would be significantly diluted by fresh groundwater.

2.3.23 2011 Groundwater Monitoring

Groundwater sampling of 65 DRA wells was conducted in May–June 2011 (Tetra Tech, 2012d). Groundwater was sampled to provide a current round of groundwater-quality data for selected monitoring wells, to evaluate time-based trends of on-site groundwater plumes, and to evaluate the natural attenuation of the chemicals of concern in groundwater at the site. Samples were chemically analyzed for VOCs, 1,4-dioxane, total and dissolved metals, perchlorate (a propellant constituent), and field water-quality indicators. Selected groundwater samples were also analyzed for TPH-DRO, TPH-GRO, radium-224, radium-226, radium-228, haloacetic acids, and natural attenuation assessment parameters.

Concentrations of TCE, *cis*-1,2-DCE, and VC for the upper, intermediate, and lower surficial aquifer zones are shown in Figures 2-24 through Figure 2-26. Benzene concentrations are shown in Figure 2-27. Findings of the 2011 VOC groundwater sampling and analyses include the following:

- Consistent with the 2010 results, concentrations of cVOCs exceed Maryland groundwater standards throughout a large portion of the investigation area, and at multiple depths. The four highest TCE concentrations observed were 13,000 μg/L in the eastern part of the site at well DMW-2A, 12,000 μg/L in wells DMW-3I (near DMW-2A) and DMW-11S (TT Median Area), and 11,000 μg/L in the eastern part of the site at well DMW-18I.
- cVOCs were at concentrations greater than groundwater standards at current site perimeter wells to the north (wells MW-14I, MW-15S/I, MW-16S/I, MW-17I, and MW-28I), east (wells MW-14I, MW-18I/S, DMW-3S/I, DMW-4S/I/D, and DMW-5S/I), and west (wells MW-24I, DMW-11S, and MW-33S).
- VOCs were not detected at wells DMW-6I/D, MW-6, and MW-32S/I, which indicates that VOC groundwater contamination is bounded along the southern portion of the site.
- Time-series plots of cVOCs in source areas and downgradient locations indicate a general decrease in cVOC concentrations since monitoring began in the early 2000s. VOC

concentrations in the source area for the TT Median Area plume (well DMW-11S) had remained steady until 2010, but decreased from the 2010 concentrations by more than 50% to historical lows for TCE and *cis*-1,2-DCE in 2011.

Concentrations of benzene exceeding the Maryland groundwater standard were limited to
wells in the PHA (e.g., DMW-9S/I/D, MW-26S, and MW-20S, DMW-1B), wells east of
Pond 1 (DMW-2S), and west of Pond 2 (MW-28I and MW-16S). Slightly more than half
of the benzene exceedances (five of nine exceedances) were in the upper surficial aquifer,
or "S," wells.

2.3.24 2011 Compass Rose Soil Investigation

The 2011 Compass Rose area soil investigation (Tetra Tech, 2012e) included surface and subsurface test pits and soil tests to evaluate any fill, debris, and soil contamination south of the DRA. Four test pits (A45 to A48; see Figure 2-28) were excavated on June 10, 2011 to evaluate possibly buried materials/debris at geophysical anomalies locations A through D (which had been identified in the 2010 geophysical survey) (Tetra Tech, 2012e). The test pits were extended downward to the depth of fill material or groundwater, or until the test pit reached 10 feet below grade.

A sample of excavated soil from each test pit was screened to characterize the lithology, make visual observations (e.g., staining, discoloration etc.), and check for odors. Soil was also screened for VOCs using a portable PID. No debris or evidence of soil impacts were observed in the test pits; therefore, only one soil sample was collected from the lowest depth of each test pit. The four soil samples collected (one from each test pit) were chemically analyzed for VOCs, SVOCs, PCBs, total metals (including mercury), TPH-DRO and TPH-GRO.

Two metals (chromium and vanadium) were detected in three or more of the soil samples at concentrations exceeding MDE residential soil standards, but less than the non-residential criteria. Detected concentrations of chromium and vanadium in all samples were less than, or within a similar range (i.e., same order of magnitude) as, their corresponding MDE anticipated typical concentrations (ATC) for metals in eastern Maryland soils. Arsenic was detected in all four soil samples at concentrations exceeding residential and non-residential standards, and the MDE ATC. Benzo(a)pyrene was detected in one soil sample (DR-TP-A45-08) at a concentration slightly greater than the residential soil criterion. Concentrations of all other detected constituents (six VOCs, five SVOCs, 10 metals, and TPH-DRO) were below their screening

criteria. PCBs and TPH-GRO were not detected in any of the June 2011 test-pit soil samples. The chemical data offer no evidence that a significant release has occurred.

Analytical data and visual observations during test pit excavations support the conclusion that a release of hazardous materials has not occurred in the investigated areas of the Compass Rose. Waste debris and impacted soils were not observed in any test pits, and laboratory analyses of soil samples indicate no evidence of a hazardous constituent release. The results of the physical and chemical analyses of test pit soils support the recommendation that no additional assessment of these four areas is necessary.

2.3.25 2011 Dump Road and Runway Area Soil and Groundwater Investigation

A June–July 2011 investigation of the DRA and runway area of MSA characterized subsurface conditions and assessed possible soil and groundwater chemical contamination (Tetra Tech, 2012f). The study included the following activities:

- advanced 20 MIP borings (MIP-76 to MIP-95) to screen for cVOCs and pVOCs in soil and groundwater in the northwestern and western portions of the DRA
- advanced 10 soil borings using DPT in the northwestern and western portions of the DRA and collected 20 soil samples for chemical analyses for VOCs, SVOCs, PCBs, total metals (including mercury), TPH-DRO, and TPH-GRO
- installed six two-inch-diameter groundwater monitoring wells (MW-30I and MW-35S through MW-39S) to approximately 20 to 40 feet below grade
- collected and analyzed groundwater samples for VOCs, SVOCs, PCBs, total metals, TPH-DRO, and TPH-GRO from the six newly installed wells

The locations and results of the MIP and DPT soil samples are shown in Figure 2-29 and 2-30, respectively. The newly installed well where primary VOCs were detected are shown in Figure 2-31. The following summarizes the investigation results:

- MIPs identified possible cVOCs at seven locations (Figure 2-29), with cVOCs considered highly elevated at four locations: MIP-84, MIP-85, MIP-86, and MIP-89. pVOCs were detected at two locations (MIP-78 and MIP-84), but at levels not considered highly elevated.
- Detected VOCs in two soil samples (Figure 2-30), SVOCs in eight samples, and TPH-DRO in four samples exceeded MDE residential soil standards. Of these results, one

VOC, five SVOCs, and two TPH-DRO concentrations also exceeded the non-residential soil standards.

- The VOC exceeding both residential and non-residential standards in soil is TCE, detected at a depth of 10 feet below grade in DR-SB27, in an area where elevated TCE results had been detected in soil-vapor samples in 2010. TPH-DRO in the sample collected at two feet below grade in this boring (DR-SB27) also exceeded residential and non-residential criteria.
- The soil boring location in which concentrations of five SVOCs exceeded both residential and non-residential criteria, DR-SB32 is in an area of probable fill between the runway and Taxiway F. The detected TPH-DRO concentration at SB-32 also exceeded residential and non-residential criteria. The detected VC concentration exceeded only its residential criterion in the soil sample collected at 14 feet below grade in DR-SB31. This result may indicate soil impacts resulting from groundwater. Moist soils were encountered at depths of six feet and below in that boring, and an unidentified odor was detected in soils collected from 10 feet below grade.
- Antimony, arsenic, cadmium, chromium, and vanadium were detected in one or more soil samples at concentrations exceeding MDE residential-soil standards. Concentrations of arsenic in 12 soil samples also exceeded the non-residential standard. Except for arsenic in several samples, cadmium and chromium in DR-SB29, and an antimony concentration for DR-SB32, all detected metals concentrations are less than or comparable to their MDE ATC values. Although the elevated cadmium and chromium concentrations in DR-SB29 exceeded their ATCs, their levels were still less than their respective non-residential standards. Arsenic is commonly detected throughout the area at relatively high concentrations, but no evidence has been found supporting an origin related to historical site use. The detected metals results were therefore interpreted as representative of typical metals concentrations in eastern Maryland soils.
- TCE at wells MW-30I and MW-39S was detected in groundwater samples at concentrations exceeding the Maryland groundwater standard (Figure 2-31). Although not shown in the figure, TPH-DRO was detected at well MW-39S (east of Pond 1) at a concentration of 3,000 µg/L, which exceeded the MDE groundwater standard by more than a factor of 60. Detected TPH-DRO concentrations also exceeded the MDE standard in groundwater samples from MW-35S and MW-37S. The detected TPH-GRO concentration in MW-30I (from the southern portion of Taxiway Tango) also exceeded its MDE groundwater standard.

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 1 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Preliminary Assessment, (Maryland Department of the Environment, 1989)	March 1989	1988-1989	None	None	None	None	None	None	None	None	The MDE, under contract to the USEPA, conducted a PA inspection of the MSA and Strawberry Point areas in 1989 to evaluate the site for inclusion in the CERCLA/Superfund NPL. The PA identified three former acid disposal pits (includes current Ponds 1 and 2), an MAA maintenance yard drum storage area, the reported historic dump site, and three buildings at MSA/Strawberry Point that housed nuclear materials research laboratories, as areas of concern. The MSA was regulated under RCRA at the time of the PA. The MDE referred the closure of the nuclear laboratories for follow-up action by MDE Center for Radiological Health and stated that no further action was warranted under CERCLA for any of theses areas.
Geophysical Survey Report, (Handex, 1992)	February 1992	October 1991	A geophysical survey consisted of the EM-31, ground penetrating radar (GPR), and limited magnetometry (LM) surveys of a 1600-foot by 200-foot area along Taxiway Tango and north of Taxiway D	None	None	None	None	None	None	None	The geophysical investigation, spurred by the encounter of four drums in July 1991, discovered large geophysical anomalies indicating the presence of metal northeast of the July 1991 drum removal area.
Preliminary Site Investigation, (MES, 1994)	May 1994	January 1994	None	15 samples SG-1 through SG-15 (thirteen collected 4 ft. bgs and two collected 3.5 ft. bgs) Analyzed for TPH, GRO, VOCs, and BTEX	16 soil samples collected (SB-1, SB-2, SB-4,SB-6 through SB-15, and PZ-1 through PZ-3). 13 SB soil samples were collected between 2 and 6 ft., and 3 PZ samples between 9 and 11 ft. Analyzed for TCLP metals, TCLP VOCs, pH, ignitability and sulfide.	None	Three wells-PZ-1, PZ-2 and PZ-3; slug tests	11 groundwater samples taken from 3 piezometers (PZ-1 through PZ-3), and 8 DPT locations (SB/GW-3, SB/GW-4, SB/GW-6, SB/GW-9, SB/GW-12, SB/GW-13, SB/GW-14, and SB/GW-15). Analyzed for VOCs, metals, and water quality parameters.	None	None	Petroleum saturated /contaminated soils were present in select samples. Soils and goundwater in the vicinity of some of these sample locations were heavily contaminated at the levels which would classify it as hazardous waste. TCE was detected in groundwater at a concentration of 92,000 ug/L and toluene at 42,000 ug/L at probe SB/GW-9 at depth of 5 to 6 feet. The extent of contamination of soils and ground water was not defined in this investigation.
Confirmation Investigation, (MES, 1995)	January 1995	July-August 1994	None	None	78 soil samples: 75 samples (2 to 12 ft. depths) from DPT borings advanced over a grid pattern; 3 samples (2 to 47 ft. depths) during installation of wells MW- 1 through MW-3. Analyzed for TPH, VOCs, SVOCs, and total metals. Select samples were analyzed for full TCLP parameters.	None	Three wells MW-1, MW-2 and MW-3; slug tests	33 groundwater samples were analyzed; consisting of 23 probe samples and 3 well samples, plus 6 duplicates and a blank. Analyzed for VOC, SVOCs, TPH, metals, sodium, and chloride.	One acid pit / pond sample; analyzed for TCLP organics and inorganics.	None	Maximum concentrations of TCE, cis-1,2-DCE, and VC detected in one probe groundwater sample located approximately 200 feet east of Taxiway Tango (in an area that appears to be between wells MW-26S/I and MW-4) exceeded the MCLs by factors ranging from more than 400 times for cis-1,2-DCE to over 1,000 times for VC. BTEX was also detected in groundwater samples, with concentrations of benzene exceeding its MCL in five probe groundwater samples. Chromium levels exceeded the MCL at four groundwater sampling locations. MES concluded that disposal of petroleum products and chlorinated solvents had an adverse impact on soils and ground water at the site. Generally the locations of higher concentrations of contaminants correlate with the anomalies found in the geophysical survey and initial field investigation conducted in January of 1994. Samples collected in the shallow water table with elevated concentrations of TPH, VOCs, and SVOCs show that the impacted soils are leaching into the ground water.

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 2 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Expanded Investigation, (MES, 1996)	July 1996	January - February 1996	None	None	15 samples from 25 DPT bore holes (B-1 through B-25) and during installation of 3 monitoring wells (MW-4 through MW-6). Analyzed for VOCs, SVOCs and heavy metals.	None	3 wells MW-4, MW-5 and MW-6 slug tests	10 samples were collected in various DPT borings using temporary well screens. 6 wells (MW-1 through MW-6) and 3 piezometers (PZ-1 through PZ-3) were also sampled. Analyzed for VOCs, SVOCs, and heavy metals.	None	Sediment sampling of two acid pits or ponds; analyzed for TCLP organics and inorganics.	Deteriorated drums were discovered northeast of Dump Road Area; contents tested TCLP hazardous for chromium; drum contents were containerized; Air photos from 1952 and 1957 show an open dump area adjacent to what is now Taxiway Tango and Acid Pit #1 (i.e., Pond No. 1). A void was found at boring B-8 and product was found at boring B-15 near the Petroleum Hydrocarbon Area. Thick smoke emissions appeared to be emanating from the vicinity of the Acid Pit area. Average hydraulic conductivity of 2.5 feet per day estimated from the wells. Performed Human Health Risk Assessment as part of the study. Select soil and groundwater samples were analyzed for full TCLP parameters.
Groundwater Monitoring Well Surveying and Sampling Report, (Tetra Tech, 1999)	May 1999	March 1999	None	None	None	None	None	6 existing wells (MW-1 to MW-6) and 1 piezometer (PZ-2) were sampled. Analyzed for TPH-DRO/TPH-GRO, VOCs, SVOCs, and metals.	None	None	Eight samples including two duplicates were collected from the six monitoring wells and one piezometer. TPH-DRO and TPH-GRO were detected at elevated concentrations in two wells. TPH-DRO only was detected at elevated concentrations in two additional wells and the piezometer. TCE was detected at elevated concentrations (exceeding its MCL) in six of the seven wells sampled. Concentrations of three other VOCs, including 1,2-DCE, tolune, and 1,1,1-TCA, also exceeded MCLs in one well (MW-5).
Source Identification and Assessment Report, (Tetra Tech, 2000)	September 2000	March-May 2000	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to clear the excavation areas.	None	83 soil samples; collected from among 11 test pit excavations, 12 soil borings, and beneath encountered drums. Analyzed for VOCs, SVOCs, heavy metals, and PCBs/pesticides.	6 Test Pit Excavations at Taxiway Tango; 4 Trenches and one Test Pit excavation at the drum-area	12 temporary wells: Pond #1 (EP1-SB1 through EP1-SB3), and Pond #2 (EP2- SB1 through EP2- SB4); and Petroleum Hydrocarbon Area (PHA-1 through PHA-5).	12 groundwater samples; one from each temporary well. Analyzed for VOCs, SVOCs, pH, heavy metals and PCBs/pesticides.	A tidal study was conducted	4 Samples collected; Pond #1 (EP1-SD1 and EP1-SD2) and Pond #2 (EP2-SD1 and EP2-SD2).	Fifteen 55-gallon and one 30-gallon drum, readings above 2000 ppmv, and inactive ordnance (consisting of a 100 pound bomb, two 1,000 pound bombs, and a 2,000 pound bomb) were discovered. Various SVOCs, metals, and PCBs were detected in soils at concentrations exeeding Maryland risk-based concentrations. Several VOCs were detected in groundwater at concentrations exceeding drinking water MCLs. Sediment samples from Pond 1 contained high concentrations of both cVOCs and pVOCs.
Chemical Delineation and Groundwater Monitoring Report (Tetra Tech, 2002)		March-October 2002	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to assure that all proposed sampling locations were clear.	None	20 Samples (7 samples from various depths in DMW-1 and DMW-2, plus duplicates) Analyzed for VOCs, SVOCs, hexavalent chromium, heavy metals, and PCBs/pesticides.	None	4 wells DMW-1A DMW-1B DMW-2A DMW-2B	6 previous wells (MW-1 to MW-6), 4 new wells, and 46 temporary wells (PA-1 to PA-16; TT-1 to TT-10; and DA-1 to DA-14, plus duplicates). Analyzed for VOCs, SVOCs, hexavalent chromium, heavy metals, and PCBs/pesticids.	None	None	All groundwater samples were analyzed for VOCs, SVOCs, Priority Pollutant Metals, TPH, hexavalent chromium, PCBs, and pesticides. All twenty soil samples were analyzed for VOCs; nineteen samples were analyzed for total priority pollutant metals, and hexavalent chromium; seven samples were analyzed for gasoline, diesel, and residual range organics; and six samples were analyzed for SVOCs.

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 3 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Data Gap Investigation and Modeling Report, (Tetra Tech, 2004a)	May 2004	September - December 2003	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to assure that all proposed well locations were clear.	None	11 Soil samples; collected in DMW-4, DMW-5, and DMW-6 at depths of major lithologic changes. Analyzed for geotechnical parameters only (porosity, bulk density, moisture content and total organic carbon).	None	28 permanent wells (DMW-1S through DMW-10S; DMW- 3I through DMW- 11I; DMW-3D through DMW-9D; MW-7) and 4 temporary wells (TT-11 to TT-14) Slug Tests	Quarterly GW sampling event of the 10 existing wells, the 28 new wells, and the 4 temporary wells. Analyzed for VOCs, SVOCs, metals, and pesticides. Select wells also analyzed for nitrate, sulfate, and iron.	None	None	The intent of the data gap investigation was to determine the extent of chemicals in groundwater plumes at the southeast portion of MSA. The specific objectives completed during the investigation were to deliniate the eastern and western extent of chemicals in groundwater, characterize VOC plumes, characterize site geology, and conduct quarterly groundwater monitoring. This groundwater sampling event was the baseline event for the upcoming quarterly sampling events.
December 2003 Quarterly Groundwater Monitoring Report, (Tetra Tech, 2004b)	May 2004	December 2003	None	None	None	None	None	Quarterly GW sampling event of the 38 permanent and the 4 temporary wells. See comments for analysis.	None	None	All Samples were analyzed for VOCs, and total and dissolved metals. Select samples were also analyzed for SVOCs. Bio-parameters consisting of nitrate, sulfate, and iron (III) were also analyzed at selected deep well locations
March 2004 Quarterly Groundwater Monitoring Report, (Tetra Tech, 2004c)	June 2004	March 2004	None	None	None	None	None	Quarterly GW sampling event of the 38 permantent wells.	None	None	The four temporary wells were not sampled and scheduled for abandonment. All samples were analyzed for VOCs, and total and dissolved metals. Select samples were also analyzed for SVOCs. Bio-parameters consisting of nitrate, sulfate, and iron (III) were also analyzed at selected deep well locations
June 2004 Quarterly Groundwater Monitoring Report, (Tetra Tech, 2004d)	September 2004	June 2004	None	None	None	None	None	Quarterly GW sampling event of 24 permantent wells.	None	None	Based on Tetra Tech's letter dated May 28,2004, MDE approved a reduction in wells sampled in the June 2004 monitoring event. All samples were analyzed for VOCs, and total and dissolved metals. Select samples were also analyzed for SVOCs. Bio-parameters consisting of nitrate, sulfate, and iron (III) were also analyzed at selected deep well locations
September 2004 Quarterly Groundwater Monitoring Report, (Tetra Tech, 2004e)	November 2004	September 2004	None	None	None	None	None	Quarterly GW sampling event of 13 permanent wells. See comments for analysis.	None	None	MDE approved a reduction in wells sampled in the September and December 2004 monitoring events. All samples were analyzed for VOCs, and total and dissolved metals. Select samples were also analyzed for SVOCs. In addition, perchlorate was added to this sampling event.
December 2004 Quarterly Groundwater Sampling Report, (Tetra Tech, 2005a)	March 2005	December 2004	None	None	None	None	None	Quarterly GW sampling event of 13 permanent wells. See comments for analysis.	None	None	MDE approved a reduction in wells sampled in the September and December 2004 monitoring events. All samples were analyzed for VOCs, and total and dissolved metals. Select samples were also analyzed for SVOCs. In addition, perchlorate was added to this sampling event.

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 4 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Groundwater User Survey Technical Memorandum, (Tetra Tech, 2005b and 2012c)	April 2005; Updated March	November 2004; 2010	None	None	None	None	None	None	None	None	A private potable well survey for the area around MSA was conducted. The survey was repeated in 2010. The survey reviewed relevant records regarding public and private groundwater users in the area, obtained current aerial photographs of MSA and environs, evaluated plume migration from the site to the closest potable well, and completed a field verification study of wells identified in the records review. Eighty-four wells in the survey area were documented as potentially being in use. A former well at 3301 Edwards Lane (i.e., the closest well to the site) was no longer used for drinking water since the property was supplied by public water. Most other residences with well records on file, lying east of Frog Mortar Creek and west of Middle River, are likely connected to public water. The survey findings suggested that no potable wells are now in use in the immediate vicinity of the site.
Additional Soil and Sediment Sampling Letter Report, (Tetra Tech, 2005c)	July 2005	May 2005	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to assure that all proposed sampling locations were clear.	None	12 soil samples collected. A sample was collected at 1 and 4 ft. bgs from 6 soil borings. Analyzed for total chromium and hexavalent chromium.		None	None	None	Four sediment samples were taken from Pond 1. VOCs, SVOCs, PCBs, total metals, hexavalent chromium, and SEM/AVS	This additional sampling was conducted to investigate hexavalent chromium concentrations in soils where elevated total chromium were detected, and also to further evaluate potential environmental risks associated with sediment chemical concentrations. Hexavalent chromium was detected at low concentrations in six soil samples with concentrations ranging from 0.36-1.4 mg/kg. Five of the six detections were in the one-foot depth samples. Three of the sediment samples had low to moderate concentrations of VOCs (including TCE and BTEX), SVOCs, metals and PCBs. Hexavalent chromium was not detected in any of the pond sediment samples.
2006 Groundwater Monitoring Event, (data collection only)	None	August 2006	None	None	None	None	None	36 wells sampled including MW-2 through MW-6, DMW-1A/B through DMW-11S/I. Analyzed for VOCs, 1,4-dioxane, perchlorate, total and dissolved metals, and hexavalent chromium. Two shallow wells (DMW-3S and DMW-9S) also analyzed for SVOCs.	None	None	Sampling results indicated that concentrations of cVOCs exceeded Maryland groundwater standards throughout a large portion of the investigation area, and at multiple depths. The maximum TCE concentration observed in a 2006 monitoring-well sample was 41,000 µg/L reported for upper surficial-aquifer well DMW-11S. 1,4-Dioxane and perchlorate were detected in 34 and 17 groundwater samples, respectively. Hexavalent chromium was not detected in the samples. Low concentrations of several SVOCs were detected at DMW-3S and DMW-9S.
Soil and Groundwater Investigation Data Report, (Tetra Tech, 2008)	June 2008	September 2007 - February 2008	A geophysical survey delineated the areal and vertical extent of possible landfill areas. The survey consisted of a reconnaissance- level EM survey and follow-up surficial gamma mapping survey to detect high-energy gamma radiation.	None	27 Soil samples collected from among 14 soil borings and 52 MIP borings (MIP-23 through MIP-75) advanced by DPT methods. Analyzed for VOCs.	50 soil samples taken from 25 test pits (A1 through A17 and N1 through N8). Analyzed for VOCs, SVOCs, metals, 1,4- dioxane, and PCBs.	(S/I/D) through MW 26 (S/I/D), and two OW wells (OW-1-	23 gw samples collected using MIP/DPT sampling, and 33 samples from new and 37 samples from existing permanent wells. Analyzed for VOCs, metals, and 1,4-dioxane.	None	None	Five 55-gallon drums and two 30 gallon containers, and PID readings up to 700 ppmv were discovered.

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 5 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Groundwater Monitoring Report, August - September 2008, (Tetra Tech, 2009b)	May 2009	August - September 2008	None	None	None	None	None	Sampled 35 wells installed before 2007 and 34 wells installed in 2007.	None	None	Samples were analyzed for VOCs, 1,4-dioxane, hexavalent chromium, and total and dissolved metals. Select samples were also analyzed for Alkalinity, chemical oxygen demand, total organic carbon, and pH.
Deep Groundwater Investigation Report, (Tetra Tech, 2009a)	April 2009	June 2008 - January 2009	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to assure that all proposed well locations were clear.	None	8 Soil samples collected. 2 Geotechnical Samples collected from each deep well boring. Evaluated for soil porosity, bulk density, moisture content and total organic carbon.	None	4 Deep Wells 1 Intermediate well MW-27D MW-28I MW-29D MW-30D MW-31D	Groundwater samples were collected from each of the new monitoring wells. Analyzed for VOCs, SVOCs, 1,4-dioxane, and metals.	None	None	The purpose of the investigation was to determine whether VOCs detected in the surficial aquifer groundwater at the MSA have migrated vertically through clay-rich sediments to the next underlying aquifer. Chlorinated VOCs such as TCE, cis-1,2-DCE, and VC were not detected in the deep confined wells. Trace to low concentrations of BTEX constituents were detected in several samples.
Groundwater Monitoring Report 2009, (Tetra Tech, 2010a)	January 2010	August - September 2009	None	None	None	None	6 Permanent Wells MW-32 through MW-34 (SI)	65 new and existing wells were sampled See comments for analysis.	None	None	Samples were analyzed for VOCs, 1,4-dioxane, hexavalent chromium, and total and dissolved metals. Select samples were also analyzed for TPH-DRO, TPH-GRO.
Remedial Investigation Report, (Tetra Tech, 2012a)	November 2010 (initial); revised April 2012	August - September 2009; Also included data from prior investigations.	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to clear the excavation areas.	None	72 soil samples taken from 25 soil boring locations (SB-01 through SB-25). Analyzed for VOCs, SVOCs, and total metals.	28 samples taken from 27 test pits (A18 through A44). Analyzed for VOCs, and total metals.	None	None	None	None	Three orphan drums and one apparent 55-gallon drum were discovered during excavation. Human health and ecological risk assessments were conducted using data from the early 2000s through 2009. Contaminants of concern included VOCs, SVOCs, PCBs, and metals.
Off-site Piezometer Installation and Water Level Monitoring, (Tetra Tech, 2010b) and Continuous Water Level Report (Tetra Tech, 2011b)	November 2010; October 2011	May-July 2010; March-April, 2011	A utility survey consisting of a combination of electromagnetic resistivity / conductivity, line locating, and ground penetrating radar was used to clear the boring areas.	None	None	None	9 piezometers PZ-1S,I,D, PZ-2S,I,D	None	None	None	Two MIPs borings were advanced and six piezometers were installed via DPT on the 3300 and 3301 Edwards Lane properties. Groundwater levels at the six piezometers and three wells at MSA were recorded every 15 minutes for one month in June-July, 2010. Surface water levels were recorded at the same interval at a tidal gaging station installed on Frog Mortar Creek. Baromteric pressure was recorded every 15 minutes at MSA. Water levels and barometric pressures were also recorded on March-April, 2011 to provide an additional set of data. The studies demonstrated that groundwater levels at the wells and piezometers responded to tidal and barometric pressure fluctuations and the data were used for DRA groundwater modeling.
Groundwater Monitoring Report 2010, (Tetra Tech, 2010c)	December 2010	July 2010	None	None	None	None	None	65 wells were sampled See comments for analysis.	3 samples collected in Frog Mortar Creek	None	Groundwater and surface water samples were analyzed for VOCs, 1,4-dioxane, hexavalent chromium, perchlorate, and total and dissolved metals,a and perchlorate. Select groundwater samples were also analyzed for RDX (an explosive compound), TPH-DRO, TPH-GRO, radium 226, radium-228 and natural attenuation parameters

SUMMARY OF DUMP ROAD AREA INVESTIGATIONS (1) LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 6 OF 6

Report	Report Date	Fieldwork Date	Geophysical Survey/Utility Survey	Soil Gas	Soil Borings	Test Pits	Well Installation	Groundwater	Surface Water	Sediment	Comments
Dump Road Supplemental Design Characterization Report, (Tetra Tech, 2011a)	April 2011	September 2010 - January 2011	Reconnaissance level EM survey was conducted for 21 acres from the southern boundary of the Dump Road Area to south of the Compass Rose area.	101 passive soil gas samples set at 4 ft. bgs. 99 samples analyzed for VOCs, TPH and diesel alkanes	None	None	None	None	None	None	Topographic surveying and a wetlands assessment of the complete Dump Road Area and Compass Rose area were conducted. Slug tests (single-well permeability tests) were conducted on 16 surficial aquifer wells.
2011 Groundwater Monitoring Report, (Tetra Tech, 2012d)	March 2012	May-June 2011	None	None	None	None	None	65 wells were sampled	6 sampling events from March to December 2011	None	Groundwater and surface water samples were analyzed for VOCs, 1,4-dioxane, hexavalent chromium, perchlorate, and total and dissolved metals,a and perchlorate. Select groundwater samples were also analyzed for RDX (an explosive compound), TPH-DRO, TPH-GRO, radium 226, radium-228 and natural attenuation parameters
2011 Compass Rose Soil Investigation Report, (Tetra Tech, 2012e)	March 2012	June 2011	Assess subsurface conditions based on elevated geophysical survey EM readings of EM anomalies A, B, C and D identified during 2010 the geophysical survey.	None	None	4 Test Pits/Excavations 4 soil samples analyzed for VOCs (8260B); SVOCs (8270D); PCBs (8082A); TPH GRO/DRO (8015B); Priority Pollutant metals (6010C, 7471A)	None	None	None	None	This investigation provided additional data, via surface and subsurface exploration and testing, to assess whether waste had been disposed of in the Compass Rose Area. This investigation also assessed the nature (e.g., mineral content) of soils in the area to discover whether these minerals may have contributed to geophysical survey anomalies found there. This study seeked to evaluate more definitively the geophysical survey findings of the 2010 DRA Supplemental Design Characterization study, which indicated that some areas near the Compass Rose Area exhibited anomalous EM responses.
Dump Road and Runway Area Soil and Groundwater Investigation, (Tetra Tech, 2012f)	January 2012	June-July 2011	None	20 MIP borings (MIP-76 to MIP-95) to screen for cVOCs and petroleum VOCs near northwest DRA, Taxiway Tango, and runway.	10 soil borings (SB26 to SB35) in northwest and western portions of DRA Analyzed for VOCs, SVOCs, PCBs, metals, TPH-GRO/DRO.	None	Installed 6 wells: one intermediate (MW- 30I), and five shallow wells (MW- 35S through MW- 39S)	Six groundwater samples (from 6 new wells) analyzed for VOCs, SVOCs, 1,4-dioxane, TPH DRO/GRO, metals, perchlorate, and hexavalent chromium.	- None	None	Highly elevated cVOC levels were identified at four MIP locations. VOCs in one soil sample (SB-27 at 10-foot depth), SVOCs in one sample (SB-32), and TPH-DRO in two samples (SB-27 and SB-32) exceeded MDE residential and non-residential soil standards. VOCs (TCE, VC, and naphthalene) were detected in groundwater samples (MW-30I and MW-39S) at concentrations exceeding the Maryland groundwater standards. TPH-DRO was detected at well MW-39S (east of Pond 1) at a concentration of 3,000 µg/L, which exceeded the MDE groundwater standard by more than a factor of 60. Detected TPH-DRO concentrations also exceeded the MDE standard in two groundwater samples (MW-35S and MW-37S). The GRO concentration in one well (MW-30I; located in southern portion of Taxiway Tango) exceeded its MDE groundwater standard.

1 Does not include investigations conducted for Frog Mortar Creek, which is located adjacent to the DRA.

Acronyms / Abbreviations:

bgs - below ground surface

BTEX - benzene, toluene, ethylbenzene, xylenes

CERCLA - Comprehenive Environmental Response, Compensation, and Liabiity Act

cis-1,2-DCE - cis-1,2-dichlroethene

COD - chemical oxygen demand

cVOCs - chlorinated volatile organic compounds

DPT - direct push technology

DRA - Dump Road Area

DRO - diesel-range organics

EM - electromagnetic

GPR - ground-penetrating radar

GRO - gasoline-range organics

GW - groundwater

LM - limited magnetometry

MAA - Maryland Aviation Administration

MCL - maximum contaminant level

MDANG - Maryland Air National Guard MDE - Maryland Department of the Environment

MES - Maryland Environmental Services, Inc

mg/kg - milligram per kilogram

μg/L - micrograms per liter

MIP - membrane interface probe

MSA - Martin State Airport

MW - monitoring well

NPL - National Priorities List

PA - preliminary assessment

PCB - polychlorinated biphenyl ppmv - parts per million volume

pVOCs - petroleum volatile organic compounds

PZ - piezometer

RCRA - Resource Conversation and Recovery Act

S/I/D - surficial/intermediate/deep (well depths)

SEM/AVS - simultaneously -extracted metals/acid-volatile sulfide

SVOCs - semi-volatile organic compounds

TCE - trichloroethene

TCLP - toxicity characteristic leaching procedure

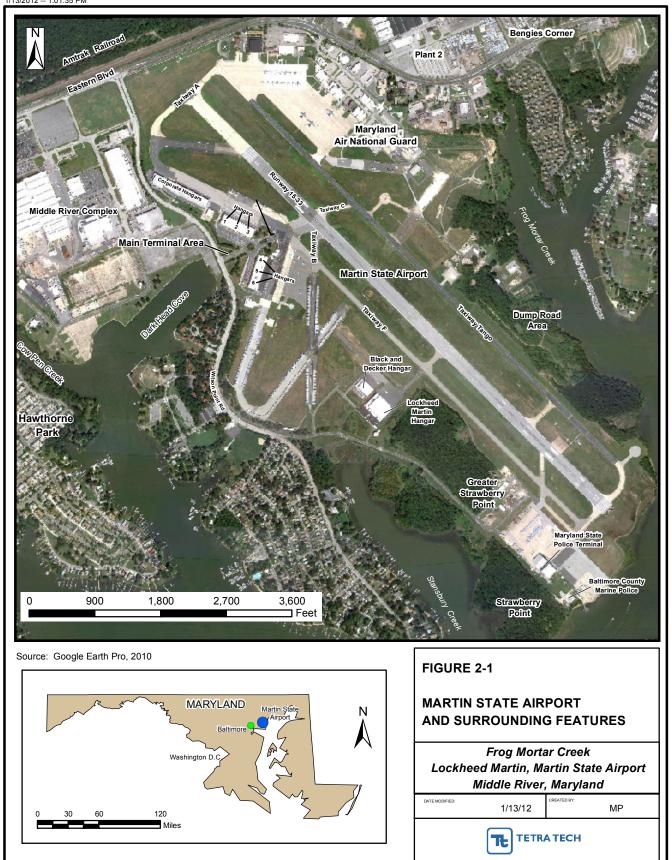
TOC - total organic carbon

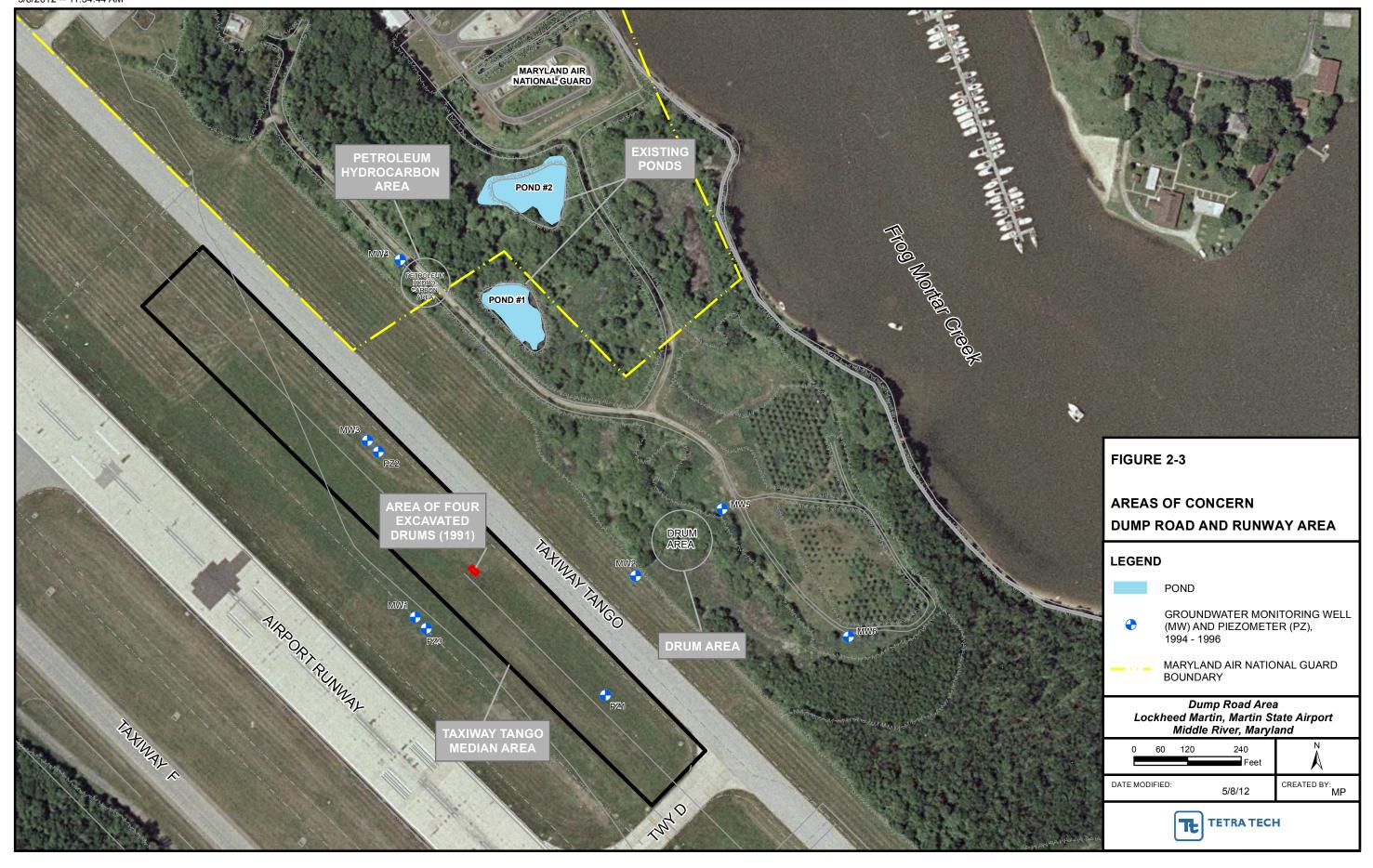
TPH - total petroleum hydrocarbons

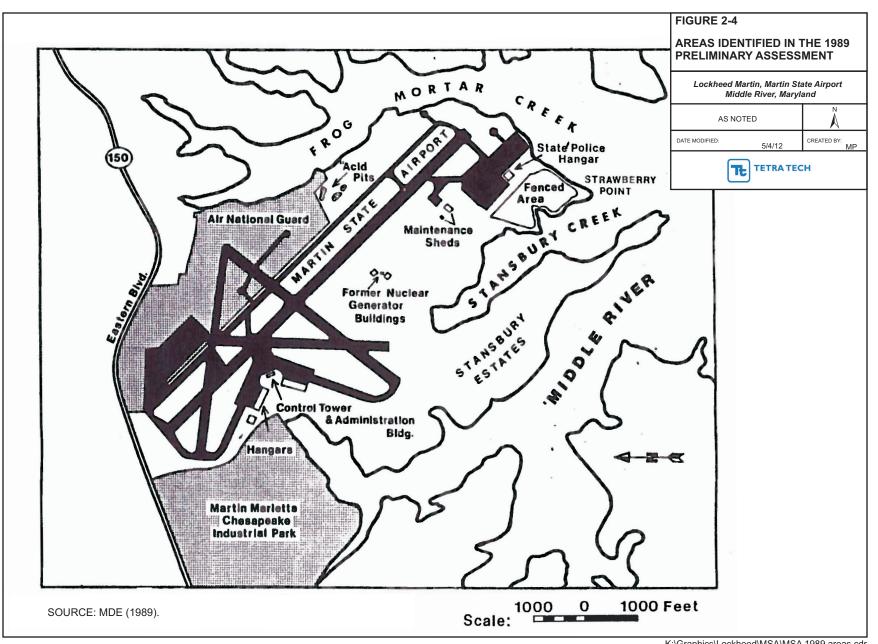
USEPA - United States Environmental Protection Agency

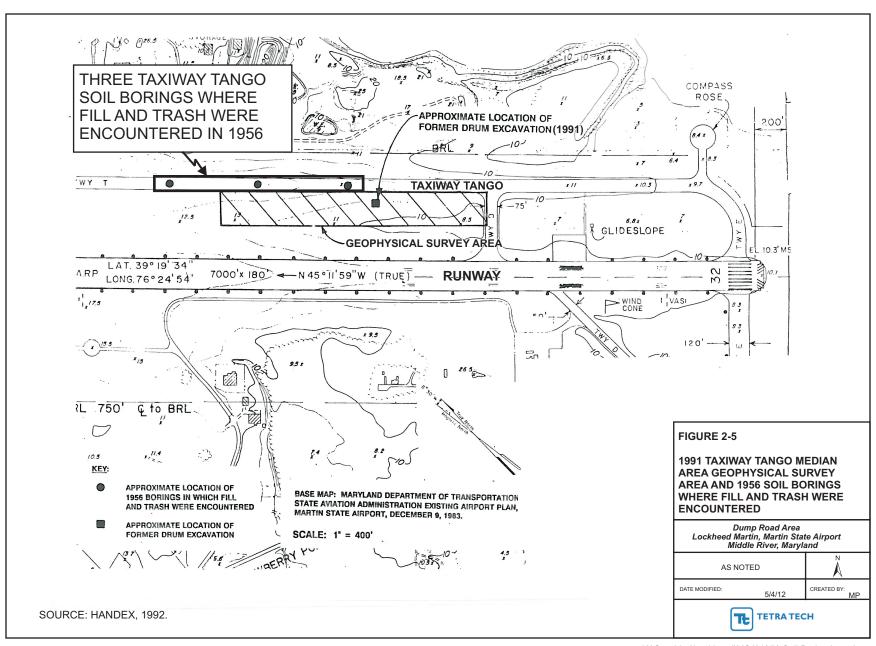
VC - vinyl chloride

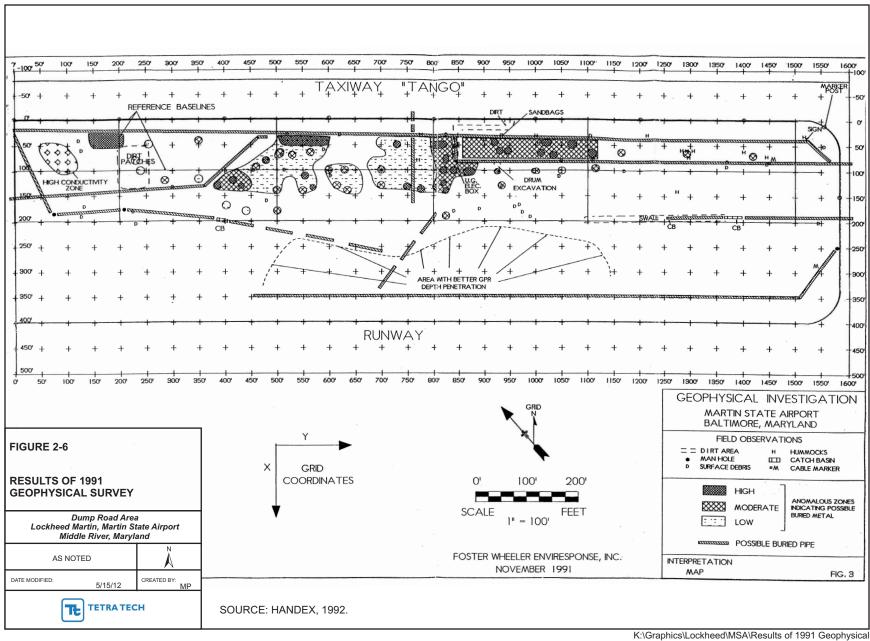
VOC - volatile organic compound

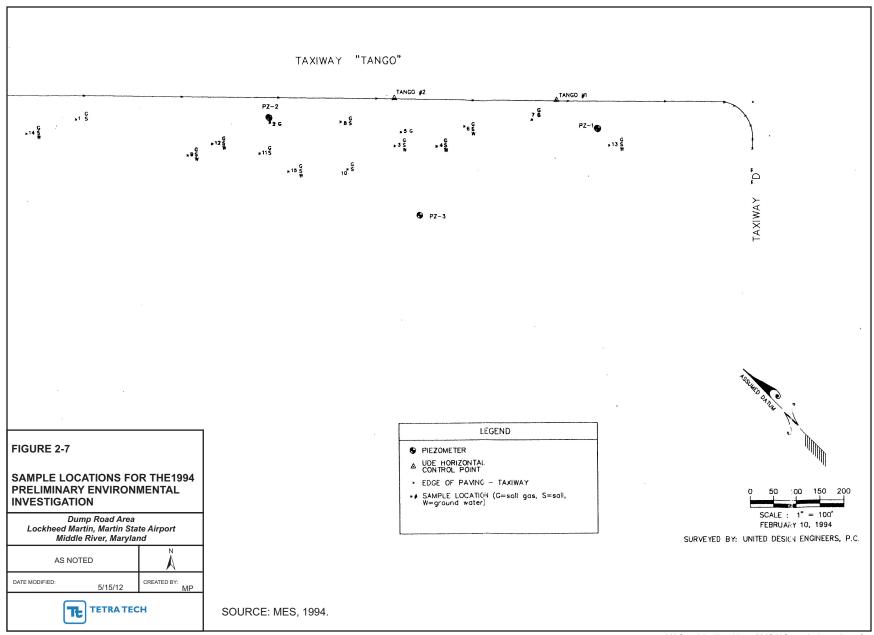


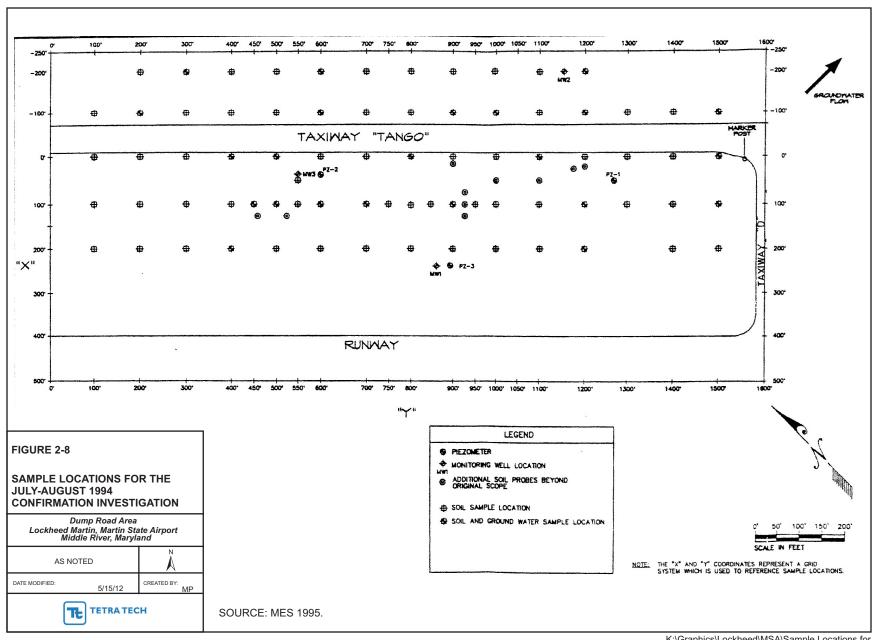


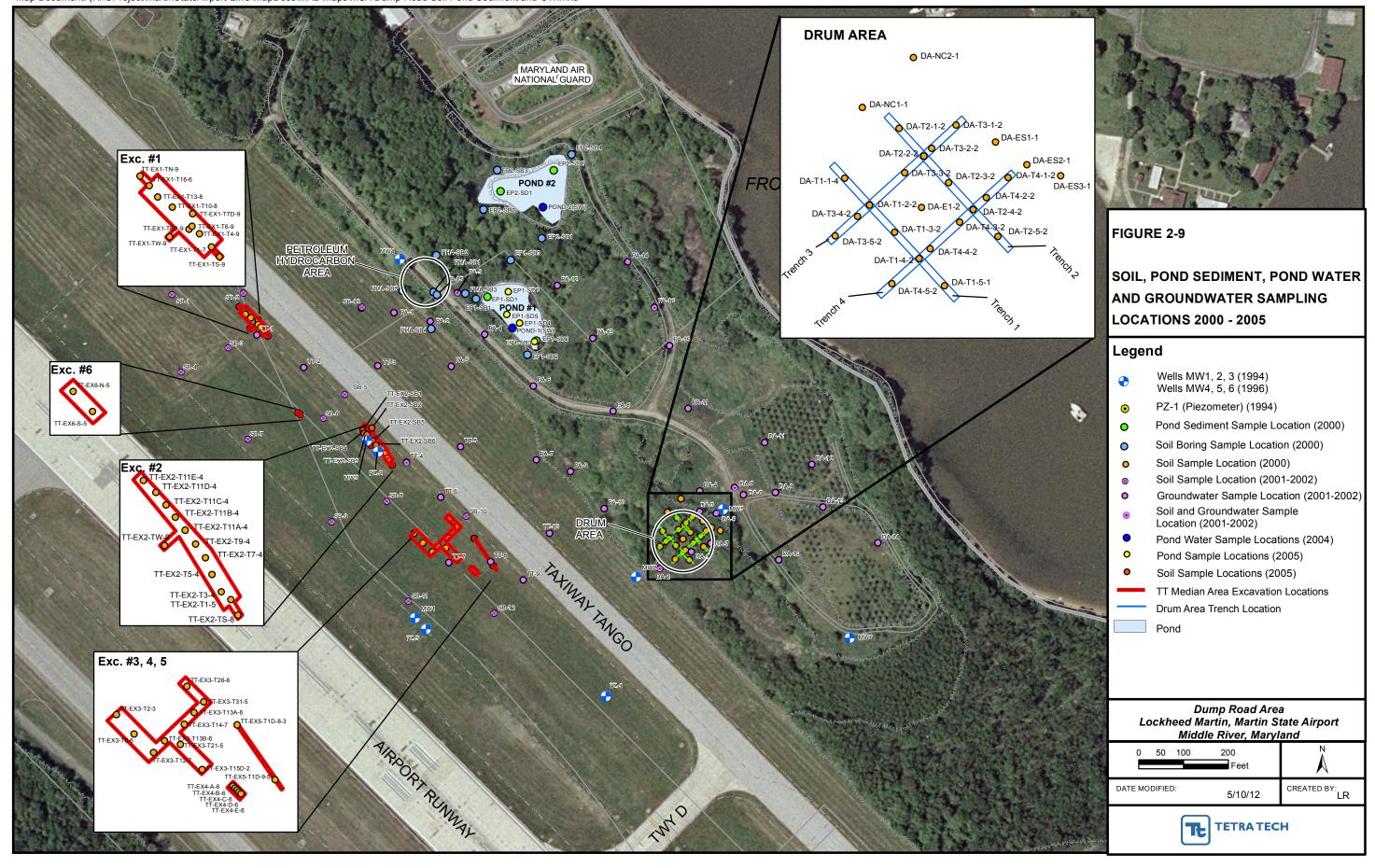




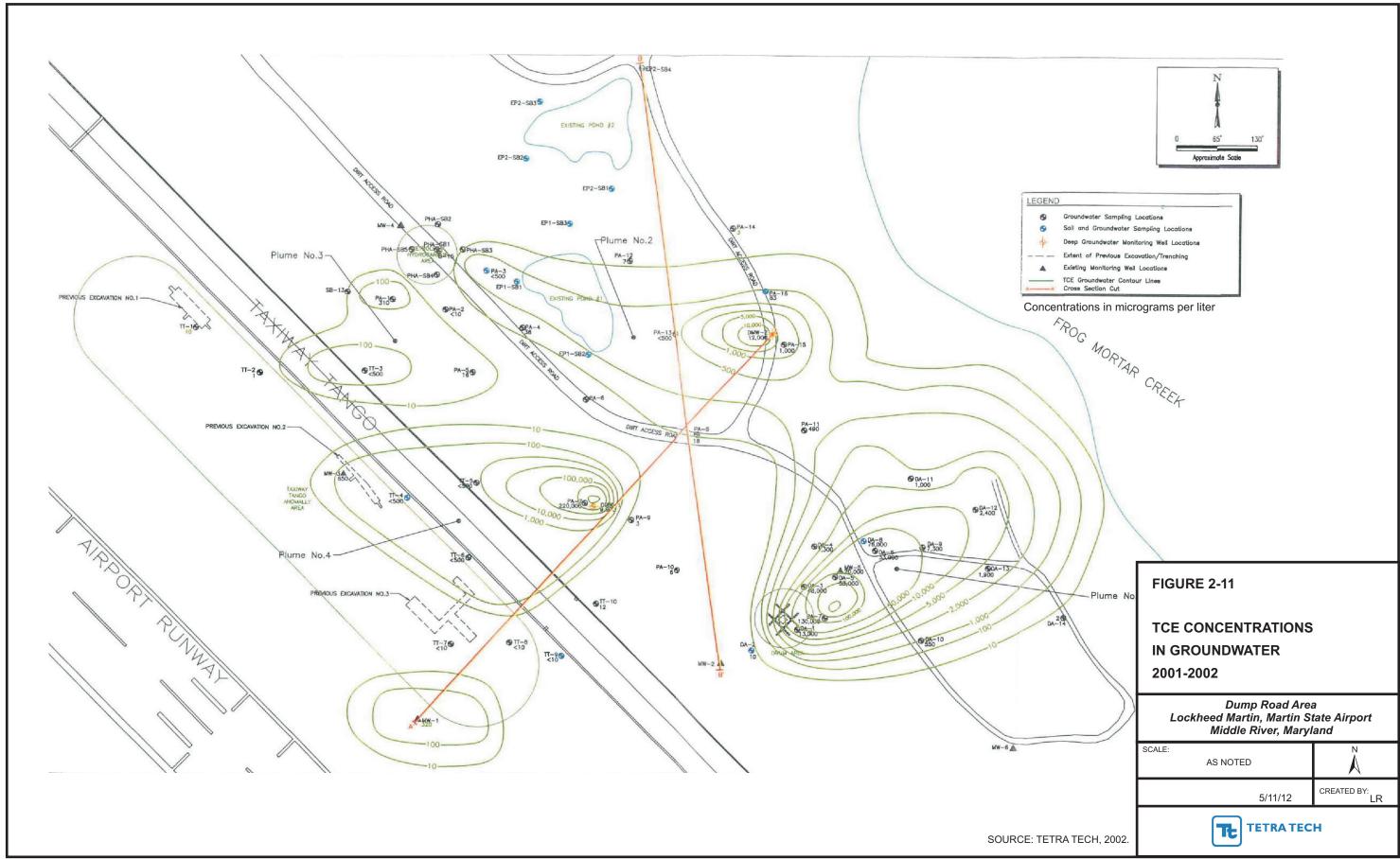


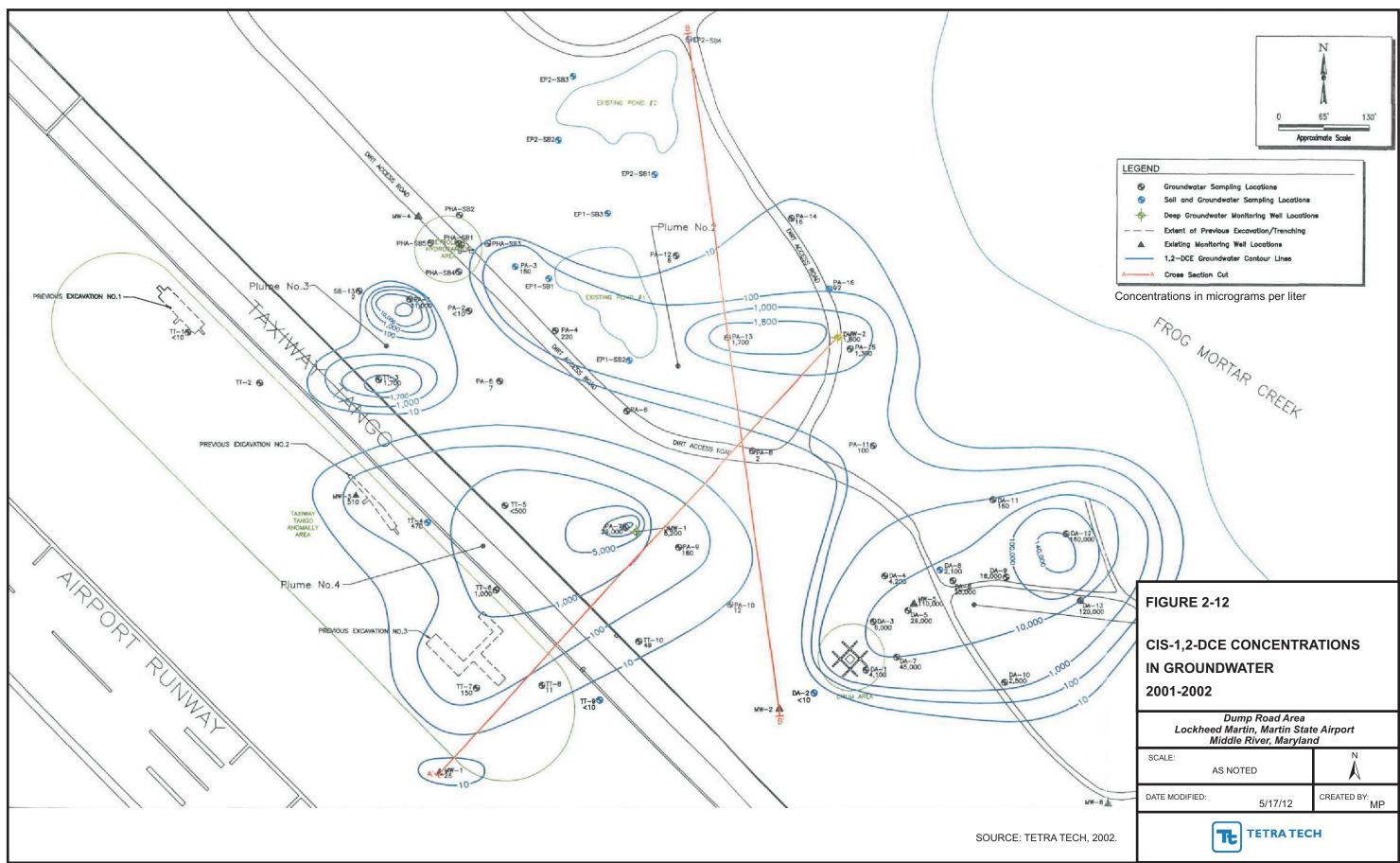


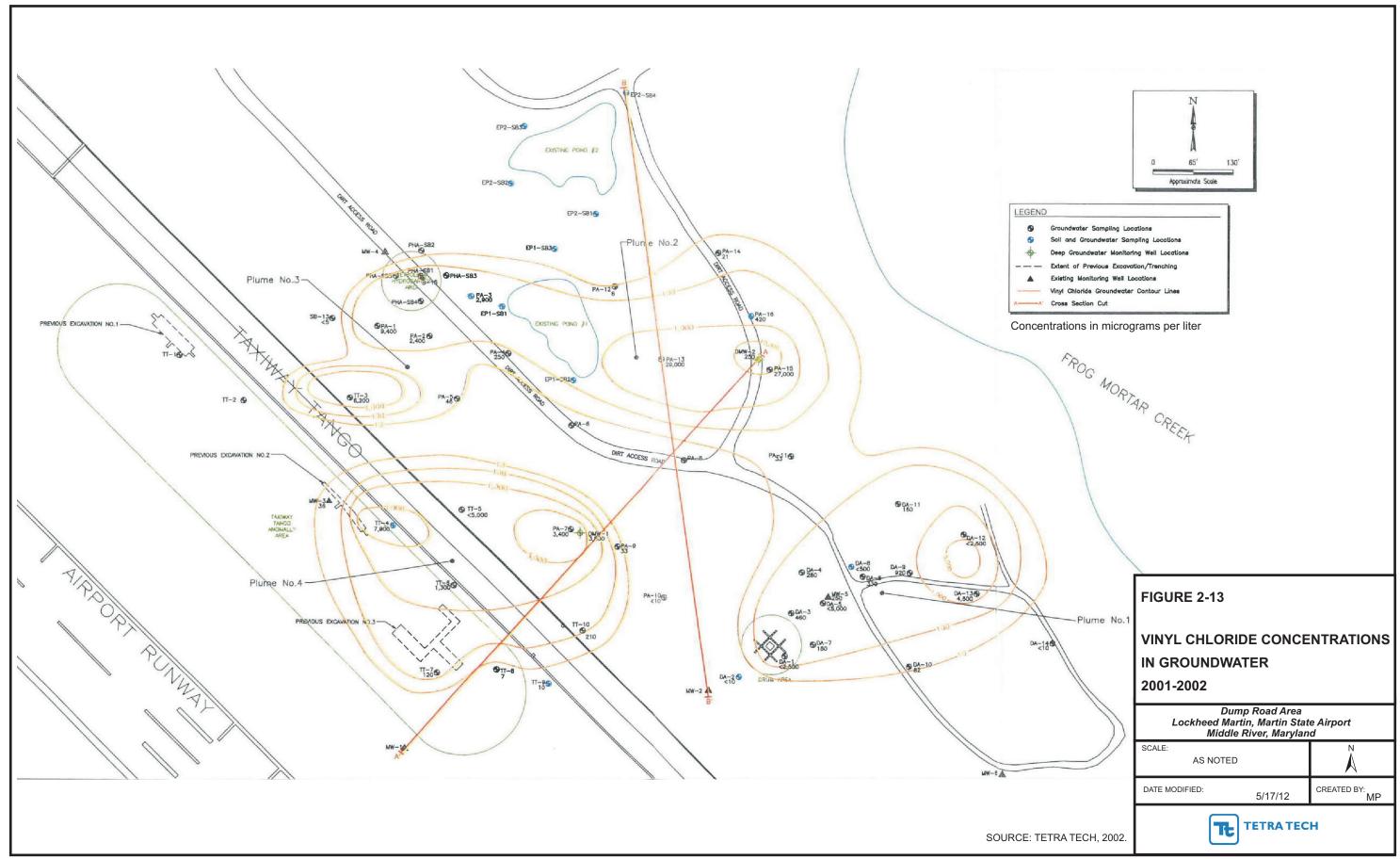


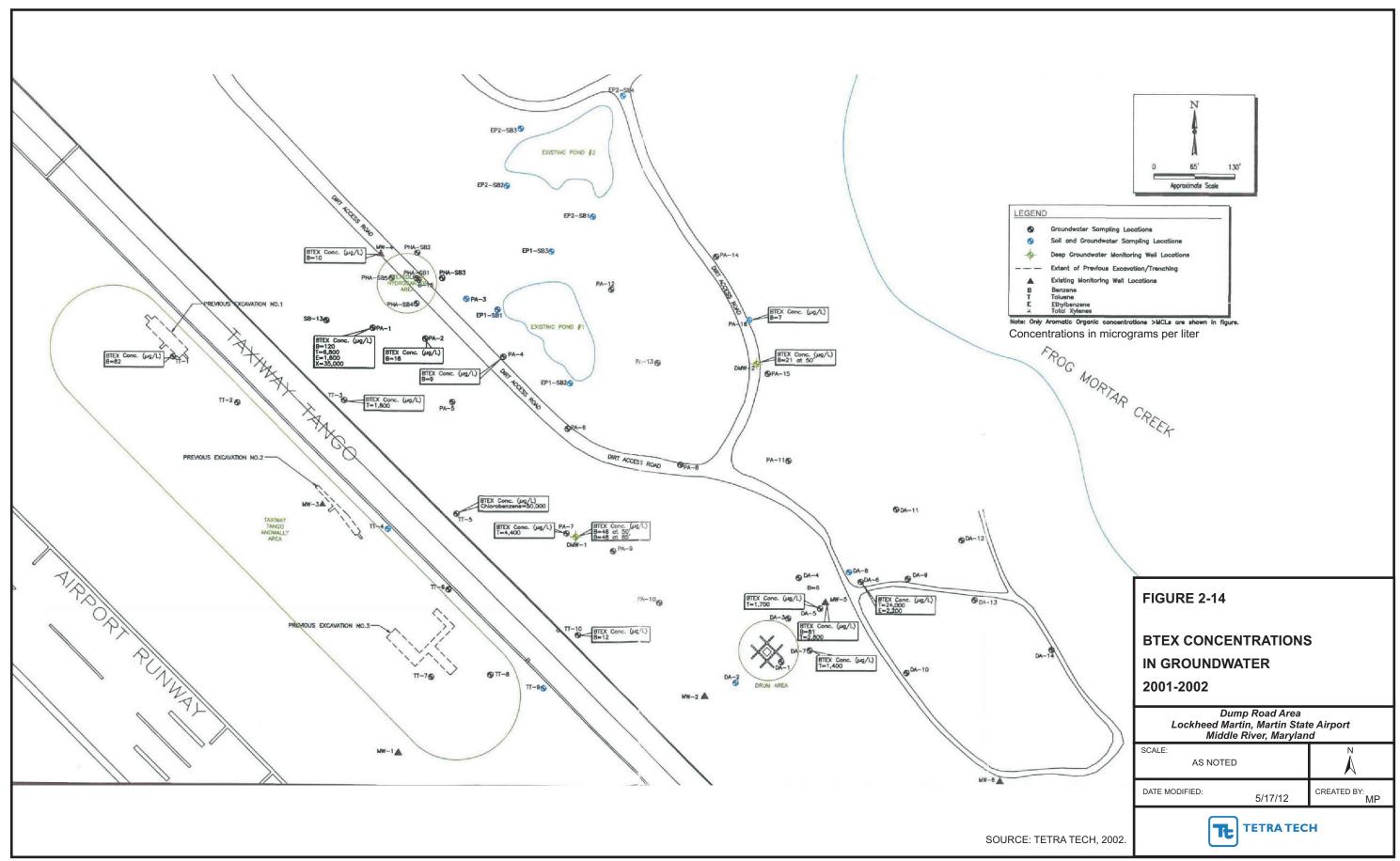


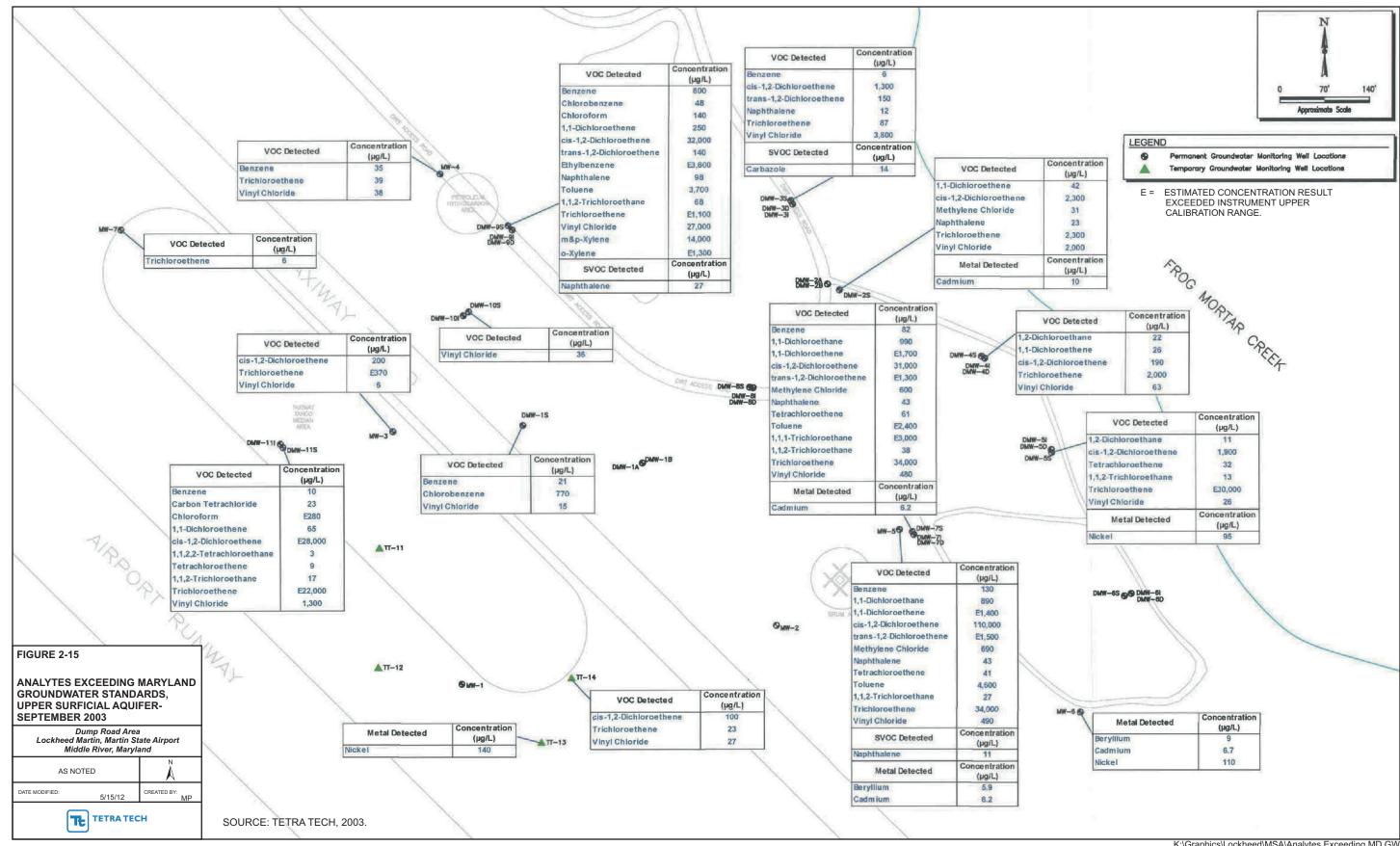


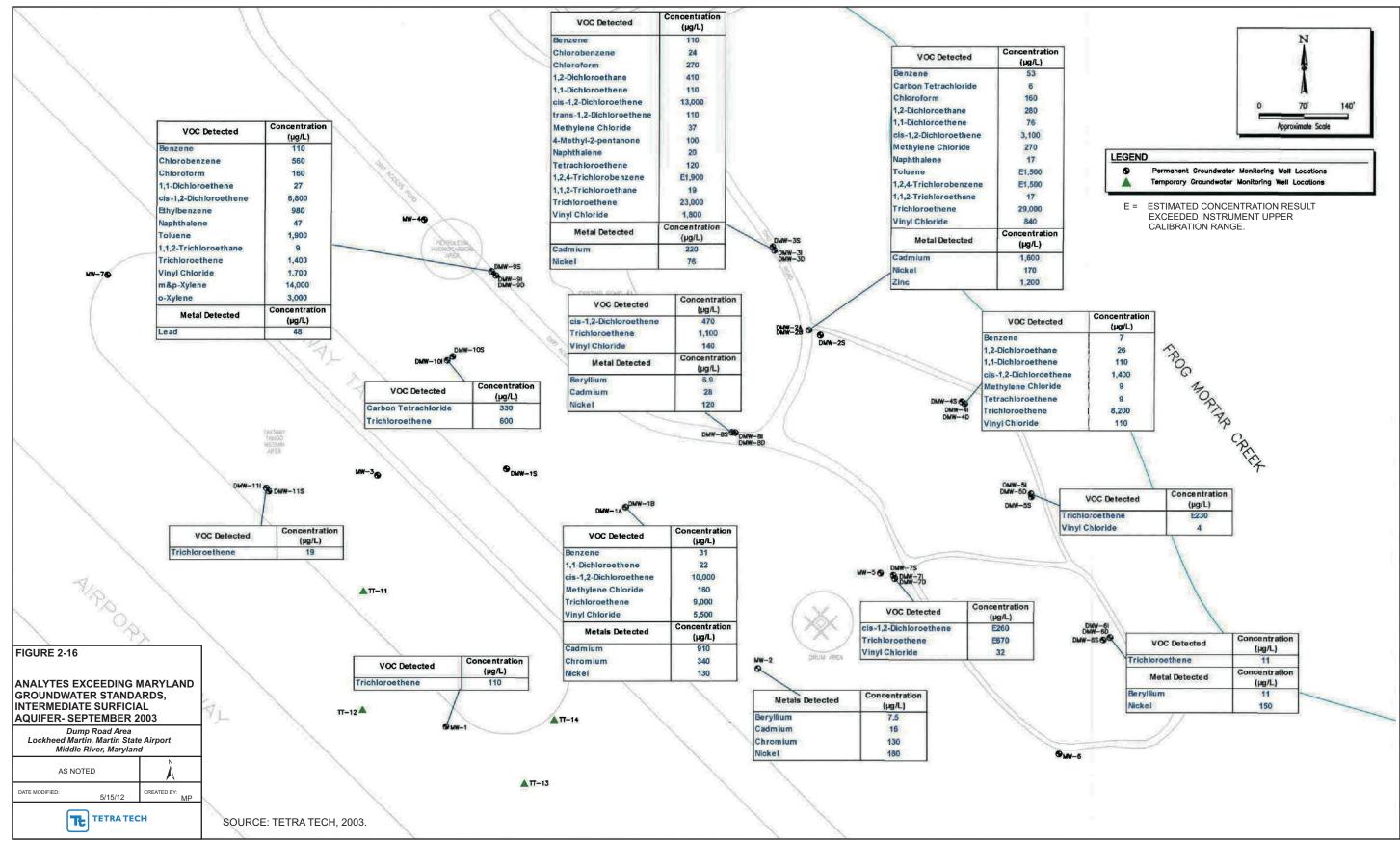


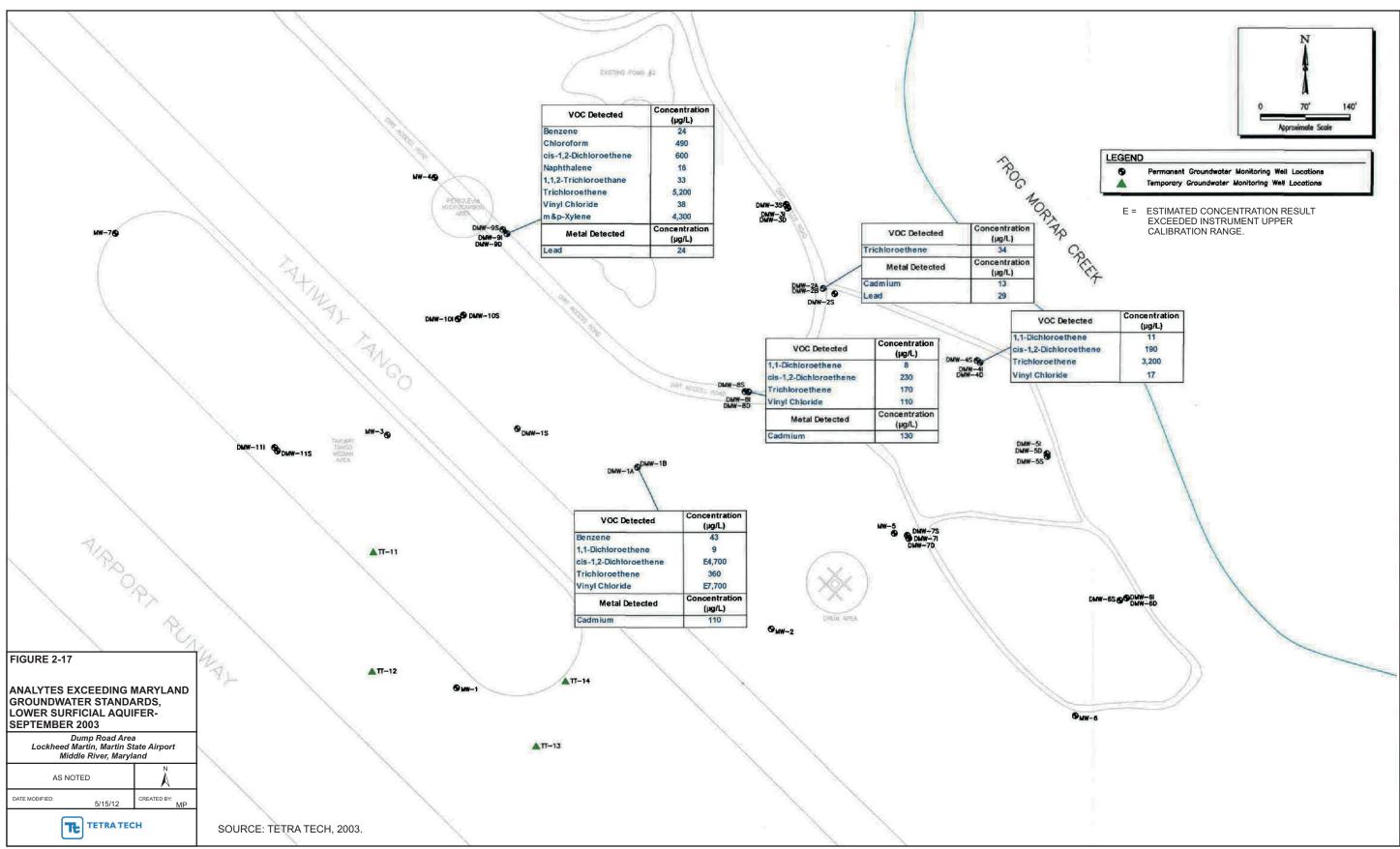


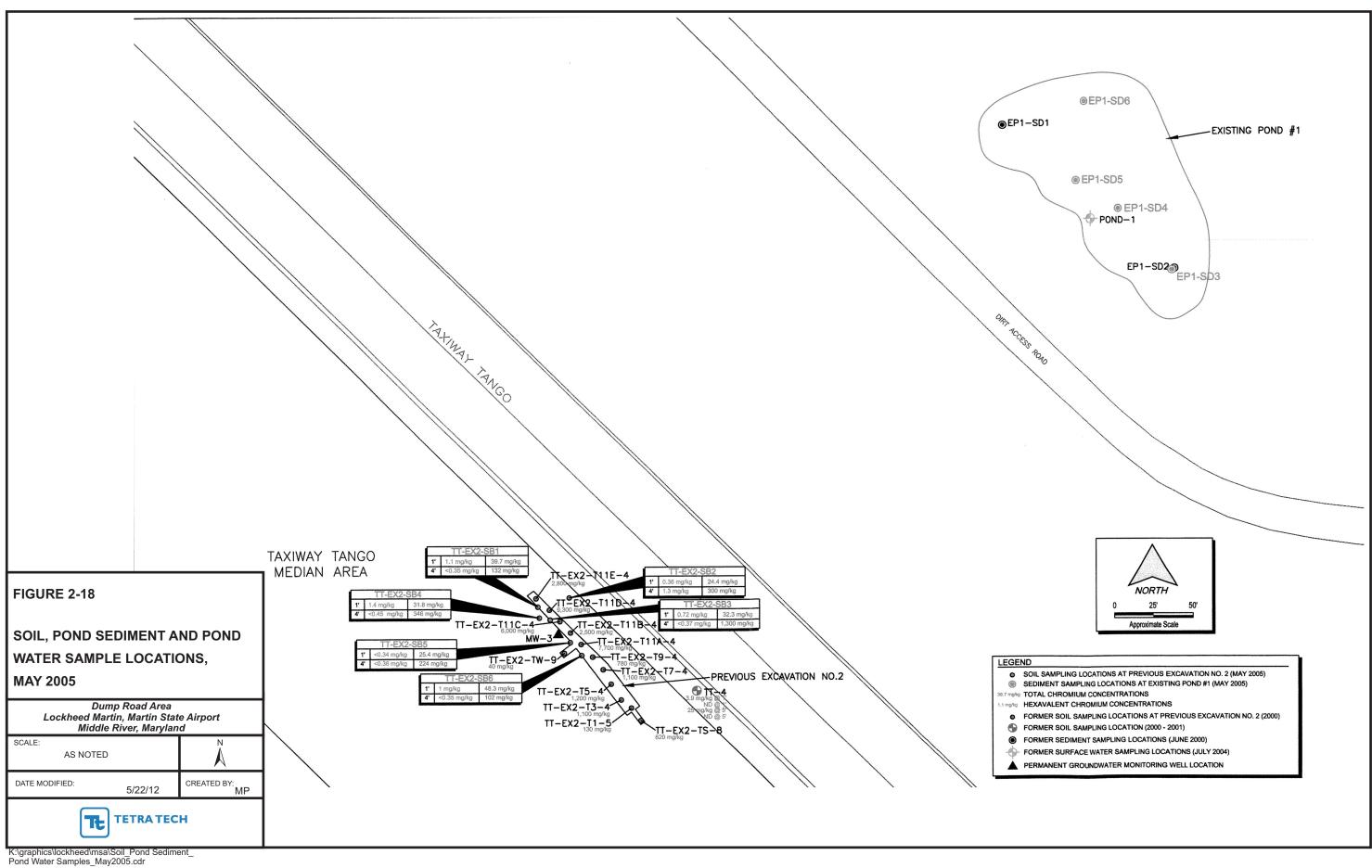




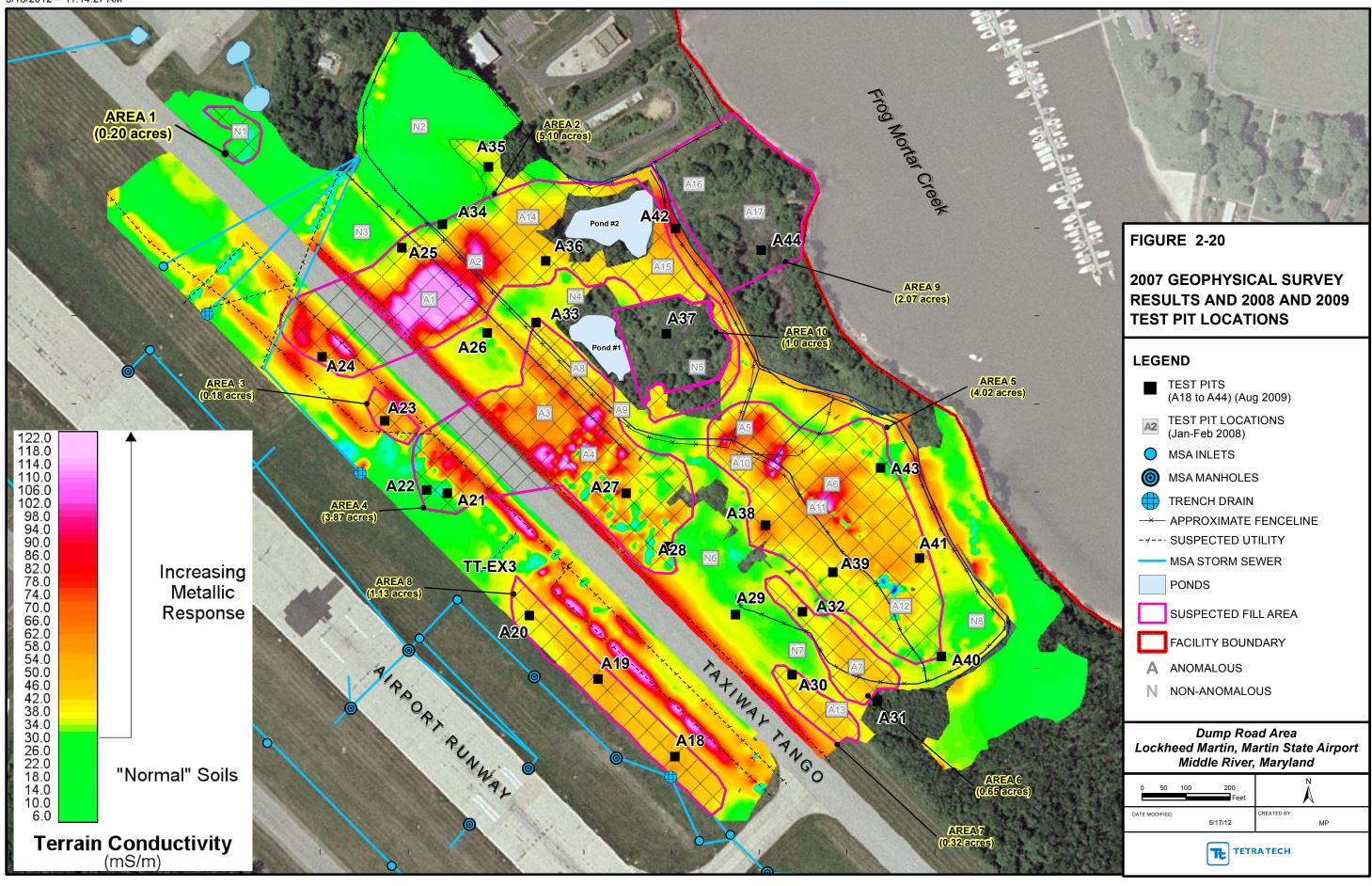


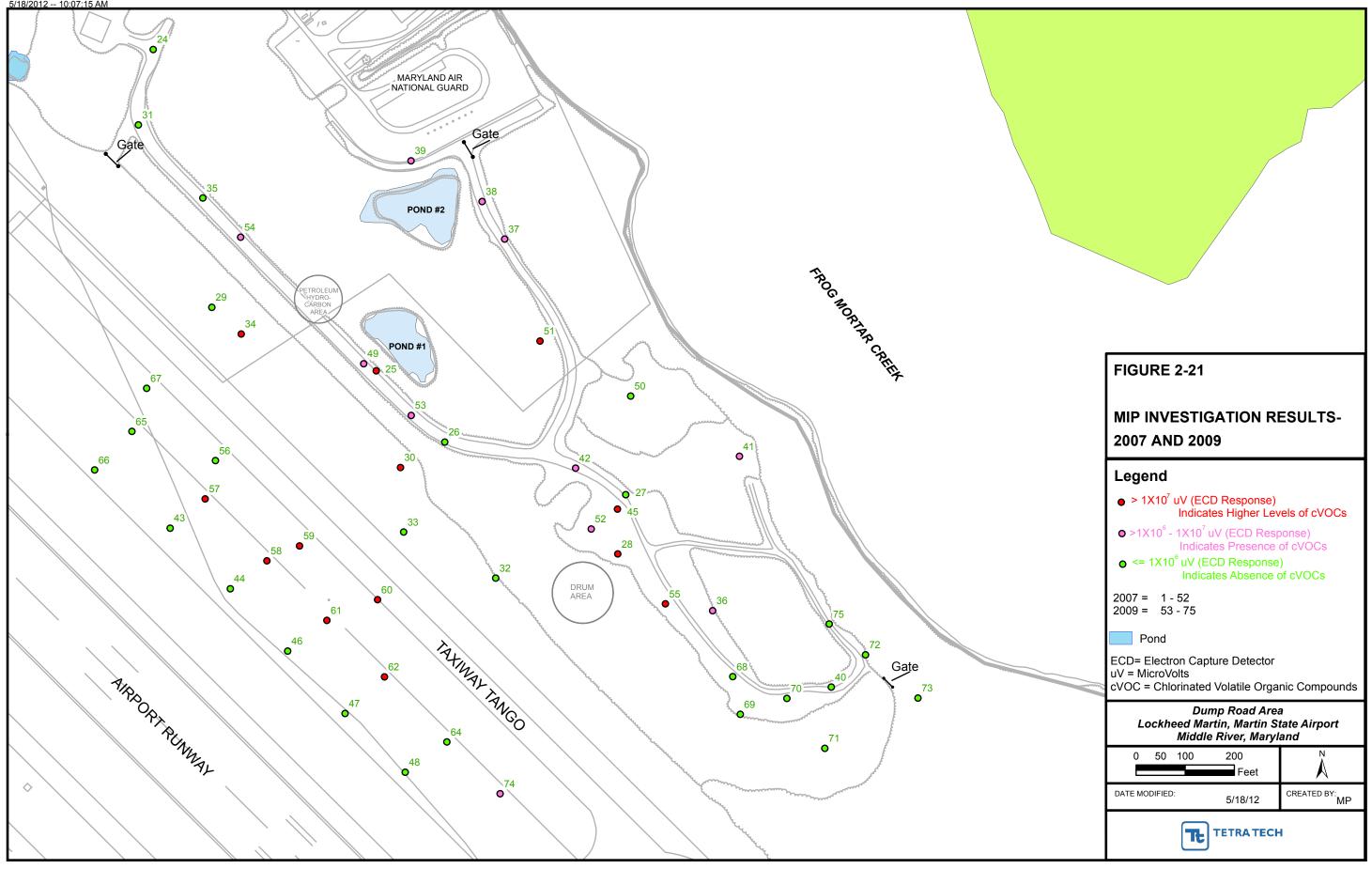


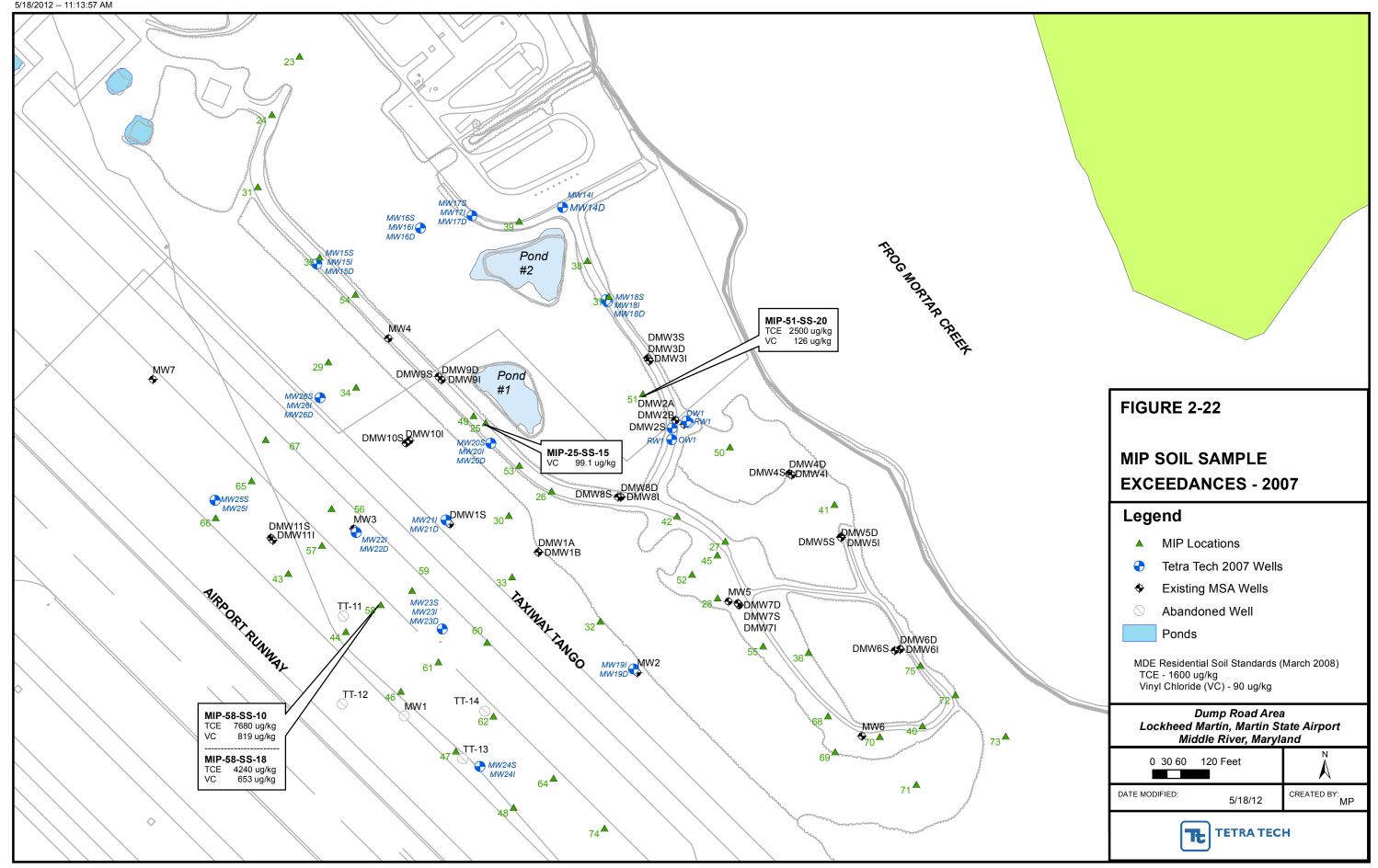


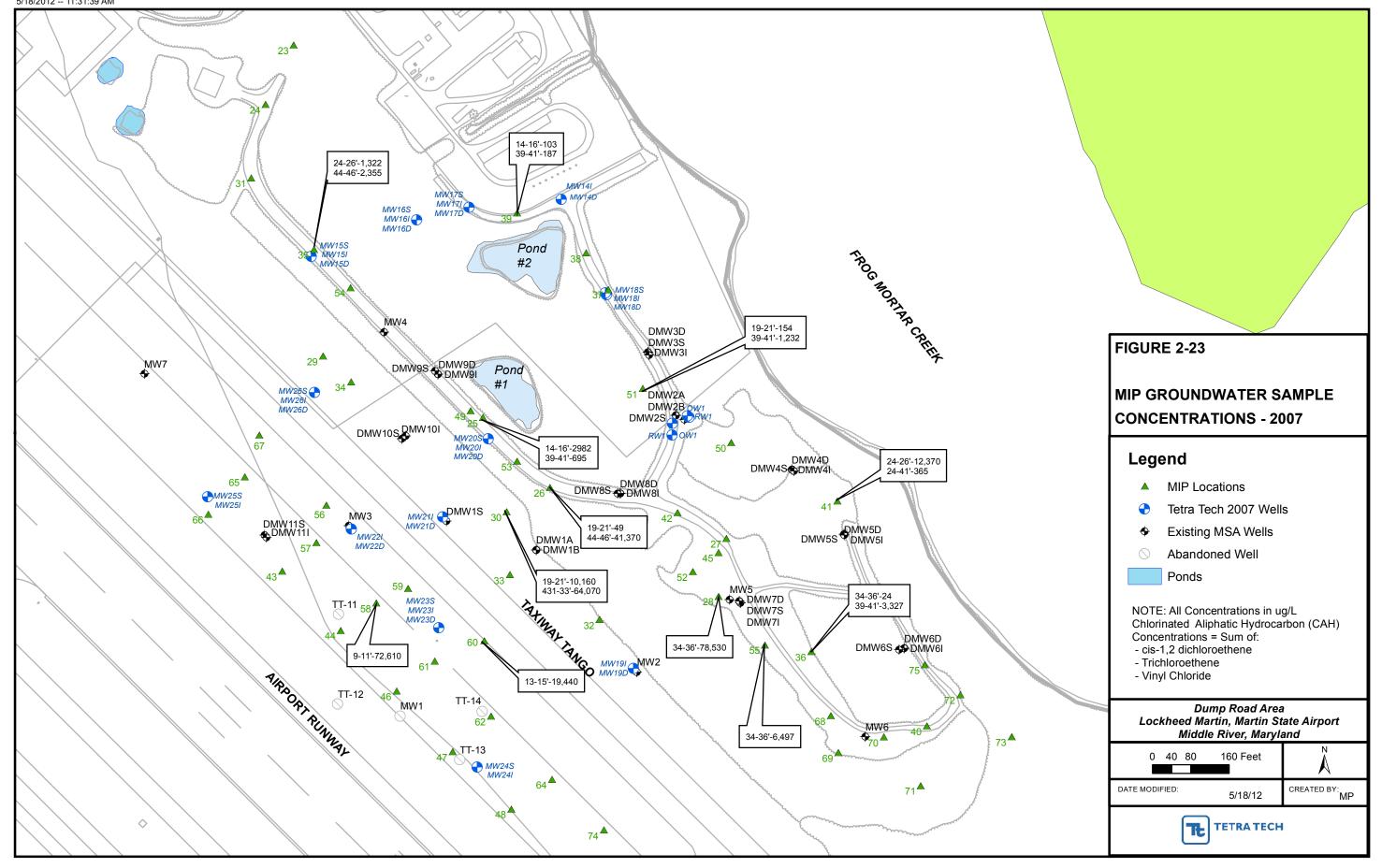












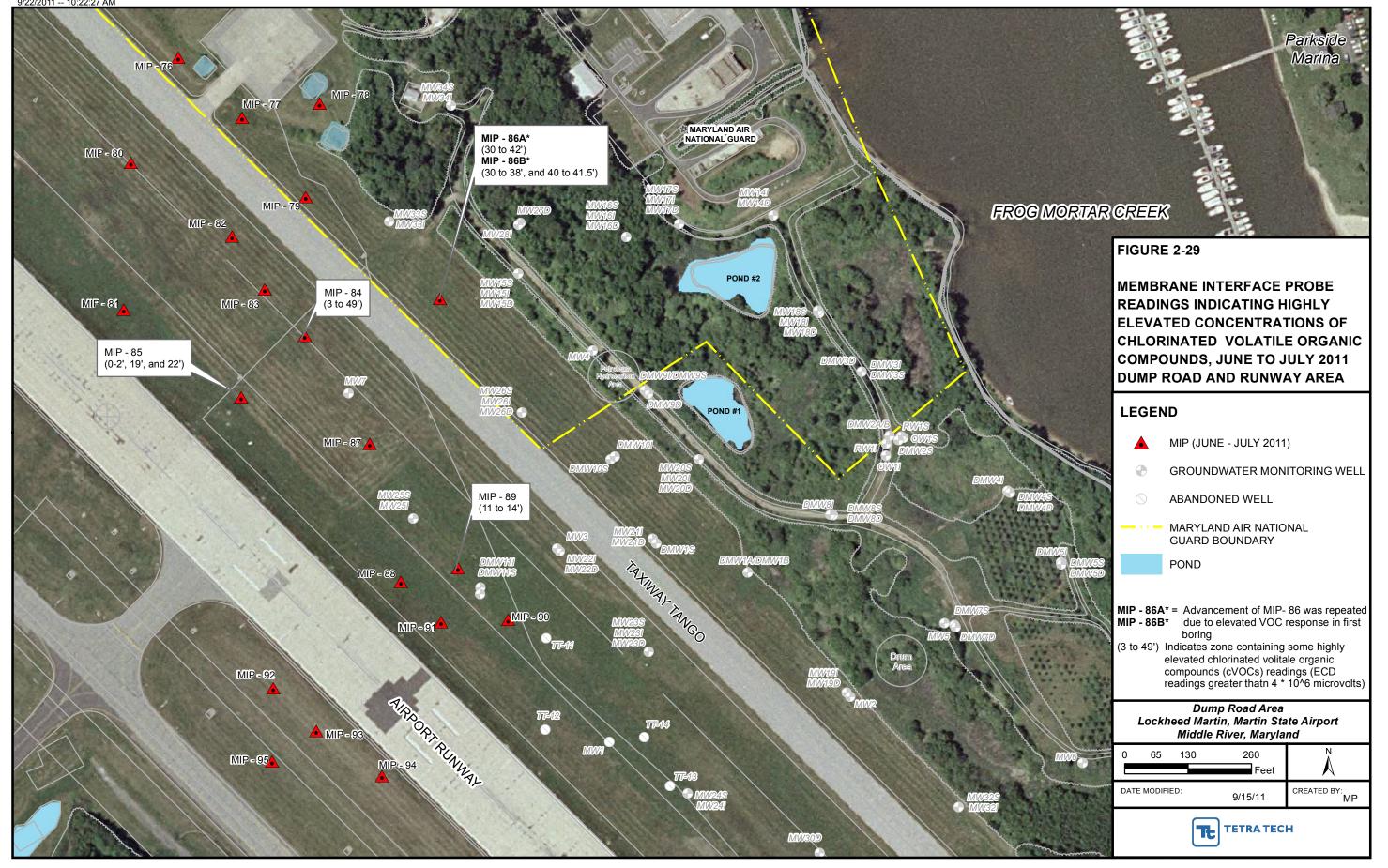


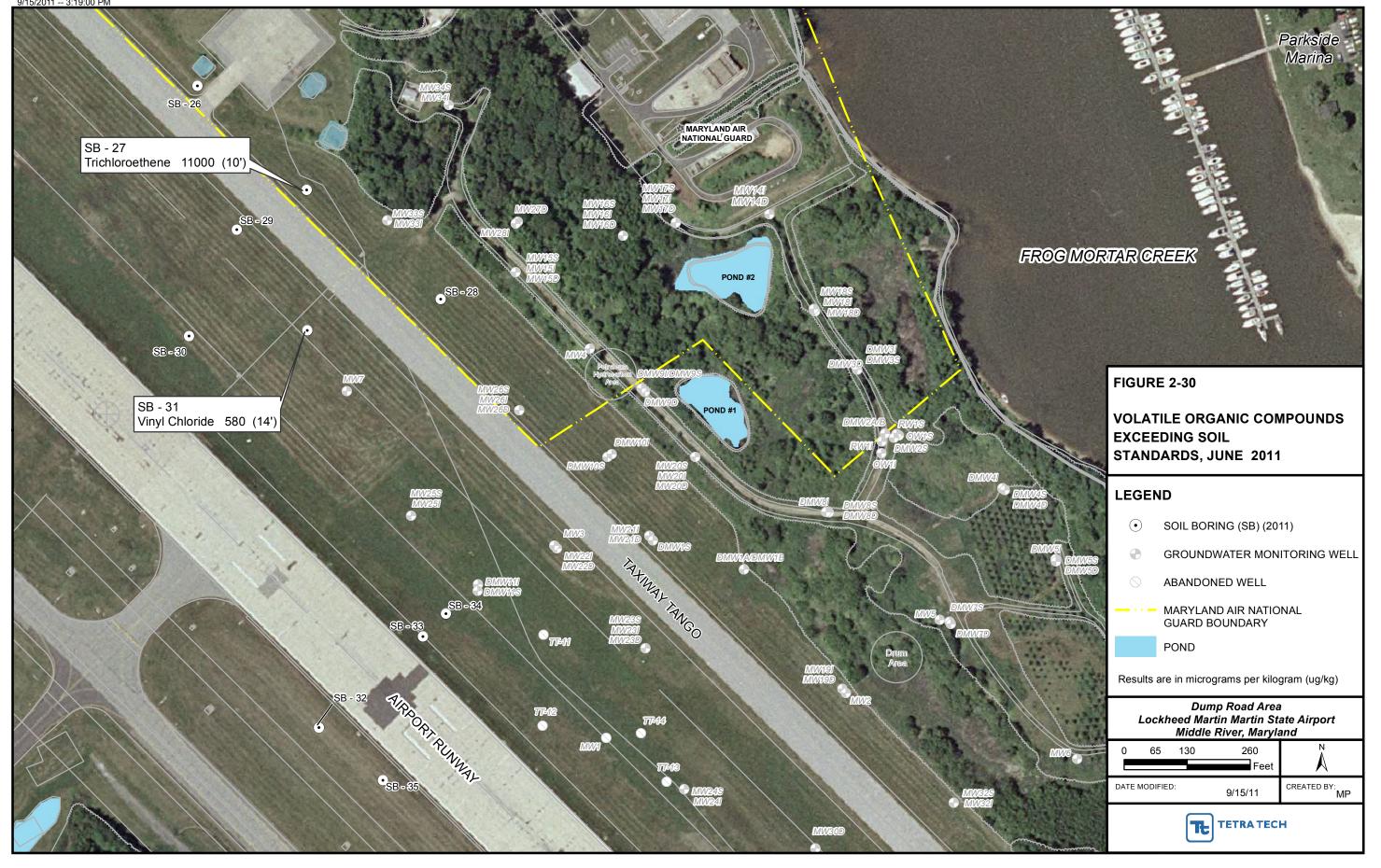














Section 3

Evaluation and Interpretation of Investigation Results

The Dump Road Area (DRA) was an unlined dump, so large areas or areas of thick fill and/or buried debris are expected to be possible contaminant source areas. Results of geophysical surveys, test pits, and soil- and groundwater-sample chemical analyses to date have been used in conjunction with hydrogeologic data to assess and define possible unsaturated-zone and saturated-zone source areas of volatile organic compounds (VOCs) at the DRA. This technical memorandum further identifies, assesses, and describes volatile organic compound source-areas at the DRA, identifies data gaps, and evaluates actions required to further characterize the source areas. Chemical results for the chlorinated VOC (cVOC) trichloroethene (TCE) and the aromatic hydrocarbons benzene, toluene, ethylbenzene, and xylenes (BTEX) were plotted in plan view and on geologic cross-sections. These chemical results were then compared to TCE saturation concentrations to evaluate the possible presence of TCE dense non-aqueous-phase liquids (DNAPLs) and areas of elevated BTEX.

3.1 EVALUATION OF GEOPHYSICAL SURVEY AND TEST PIT RESULTS

The results of a 2007 geophysical survey of the DRA and contour maps of the depth and thickness of buried fill and debris areas of the DRA were used to identify possible contaminant source areas. The maps of the fill and debris are based on the results of test pits excavated throughout the site in 2000 and 2007–2009. Test pits provide a method of exposing and identifying fill and debris and directly measuring depth and thickness.

3.2 EVALUATION OF SOIL SAMPLING CHEMICAL RESULTS

TCE and BTEX results for soil samples were divided into three soil categories: samples collected up to two feet deep (surface soil), samples collected between two- and 15-feet (shallow subsurface soil), and samples collected at depths greater than 15 feet (deep subsurface soil). Surface soil (soil at depths of zero to two feet) samples are typically used to evaluate risk to

human health by direct contact with soil; it is also expected indicate VOC sources from surface spills or leaks.

Surface soil also represents the upper portion of the vadose or unsaturated zone at the DRA. Subsurface soil at the DRA is defined as the shallow portion of the unsaturated zone down to the average depth to the water table. Deep subsurface soil typically represents soil in the saturated zone of the surficial aquifer at the DRA.

Soil data were plotted and contoured in plan view for each of the three categories. Soil results were also plotted on geologic cross-sections along with the groundwater sampling results. The contour maps and cross-sections provide the basis for determining the locations and depths of areas of elevated VOC concentrations in soil at the DRA.

3.3 EVALUATION OF GROUNDWATER SAMPLING CHEMICAL RESULTS

Groundwater at the DRA site has been assessed in three depth zones to better characterize VOC concentrations in three dimensions. The three zones are defined as the upper ("S" wells), intermediate ("I" monitoring wells), and lower surficial—aquifers ("D" monitoring wells, or deep). The upper surficial aquifer extends from the groundwater surface (approximately eight to 15 feet below grade) to approximately 30 feet below grade. The intermediate surficial aquifer is approximately 30 to 60 feet below grade, and the lower surficial aquifer is approximately 60 to 90 feet below grade. Descriptions of the surficial aquifer are in Section 2.

Groundwater data from the 2011 round of monitoring well sampling were used for the analyses. Several wells (DMW-2B, MW-2, DMW-7S, DMW-7I, DMW-7D, and DMW-5D) were not sampled in 2010 or 2011. Therefore, chemical data from 2007 or 2008 were used for these wells. Chemical results from temporary well samples collected in 2002 (e.g., TT-1, PA-1 and DA-1 groundwater samples), and the 2007 DPT groundwater samples (e.g., MIP-28) are plotted along with the upper surficial aquifer well data.

Note that DPT probe samples (e.g., MIP-28) or temporary wells can yield higher concentrations of cVOCs than samples collected from long-term monitoring wells, because DPT and temporary well groundwater samples reflect smaller, discrete sampling intervals. The smaller sampling interval can isolate the more highly contaminated portions of the aquifer from less contaminated portions

during groundwater sampling. In this way, DPT and temporary wells are considered more effective in developing detailed vertical profiles of contaminants in the subsurface and for assessing dense non-aqueous-phase liquids (DNAPLs). DPT sampling is particularly effective when groundwater samples are collected at multiple depths from the top of the water table to the base of the target aquifer. DPT sampling programs can thus be used to rapidly delineate contaminant concentrations in three dimensions and to plan for the installation of groundwater monitoring wells.

Groundwater data for "TCE equivalents" (TCE_{EQ}), TCE, and total BTEX were plotted and contoured in plan view for each aquifer level. Groundwater chemical results were also plotted on geologic cross-sections along with the soil sampling results. The TCE_{EQ} concentration of a groundwater sample is a "parent-product concentration" that includes its concentration of TCE plus the molar equivalent concentrations of primary TCE-degradation or "daughter" VOCs, such as cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC).

The TCE_{EQ} concentration is typically higher than the concentration of TCE alone if biodegradation is occurring. However, the TCE_{EQ} concentration may be more effective in identifying possible DNAPL zones, since TCE_{EQ} is a concentration of TCE *plus* the amount of TCE that would be required to produce the detected concentrations of daughter products. The contour maps and cross-sections generated from the available data provide the basis for determining the locations and depths of elevated VOC concentrations in groundwater at the DRA.

3.4 DNAPL ASSESSMENT

TCE, a strong industrial degreaser used in machining operations, is the primary parent VOC of concern at the DRA. Its historical use at MSA has produced large groundwater plumes of dissolved TCE and its degradation or "daughter" VOCs *cis-*1,2-DCE, VC, ethane, and ethene. TCE has a low solubility in water and is more dense than water. Its physical characteristics are such that it could be in the subsurface in the form of DNAPL, or what is known as "product form."

TCE DNAPL degrades slowly in most subsurface environments, so it persists as a long-term source of dissolved-phase VOC contamination. The location of DNAPL determines the spatial distribution and concentrations of VOCs in the plume. The delineation of DNAPL in the

subsurface is an important component of a conceptual site model and is critical to selecting the proper remedial approach (Kueper and Davies, 2009).

When product is released to the subsurface, DNAPL will become distributed in disconnected blobs and ganglia of organic liquid within the soil, referred to as "residual DNAPL." If sufficiently large volumes of product are released, the ganglia may become connected and form pools of DNAPL. Residual DNAPL can be found above and below the water table along the DNAPL flow pathway in the soil column where it was released. Residual DNAPL is trapped (i.e., immobilized) within the soil by capillary forces, but its presence can result in dissolved-phase plumes of contamination in groundwater for decades to hundreds of years.

DNAPL pools, on the other hand, represent a connected distribution of DNAPL and can flow vertically and horizontally as "product" in the subsurface. DNAPL pool-spreading can increase the size of the DNAPL source area, which then contributes to the dissolved-phase plume over time. DNAPL spreading can be parallel to groundwater flow or in other directions. For example, DNAPL in pools may migrate along low-permeability barriers that may dip away from groundwater flow, or within rock or saprolite fractures that may radiate in several directions (Kueper and Davies, 2009).

The U.S. Environmental Protection Agency (USEPA) provides a multi-step process for evaluating DNAPLs in the subsurface at hazardous waste sites (Kueper and Davies, 2009). Determining whether DNAPLs are in the subsurface involves many uncertainties, so USEPA recommends using converging lines of evidence to assess whether DNAPL is present. These lines of evidence are used in this study to evaluate whether DNAPLs are in soil and/or groundwater at the DRA. The following sections describe the recommended DNAPL source-zone investigation methods (Kueper and Davies, 2009).

3.4.1 Soil Methods

DNAPL typically migrates through the subsurface in a very selective and meandering manner. It may be present as residual DNAPL distributed in noncontiguous portions of the soil column. A significant portion of the contaminant mass may have diffused into lower permeability zones. DNAPL migration can occur within thin lenses and laminations of soil at the scale of inches or less (Kueper and Davies, 2009). Some DNAPLs are colorless and not readily visible in soil.

DNAPL in soil can also vaporize into air-filled pore spaces, which creates vapor-phase plumes, but also lowers contaminant concentrations in the soil over time. DNAPL persistence in soil may be short relative to its persistence in groundwater; therefore, the absence of DNAPL in the unsaturated zone may not be sufficient evidence to conclude that DNAPL has not migrated to below the water table. Further, flushing the upper portion of the water table via recharge and downward hydraulic gradients in many aquifer systems may reduce groundwater concentrations near the top of the water table and mask higher contaminant concentrations in deeper portions of the aquifer.

3.4.1.1 Visual Observations

DNAPL may be directly observed in soil or groundwater samples. DNAPL can be observed in drill cuttings or soil samples collected during drilling. DNAPL in groundwater may be observed in groundwater samples collected at the bottom of a well using a bailer or measured using an electronic water level and product interface probe.

Soil boring logs, well drilling logs, and test pit logs to date indicate elevated field screening levels detected using a portable photoionization detector (PID). The logs provide limited indications of any visual observations of DNAPL. As part of the 1996 expanded investigation conducted for the Maryland Aviation Administration (MAA), soil at a depth interval of 12-14 feet in boring B-8 was reported to have a strong odor and had a high total VOC reading (greater than 2,500 parts per million) using a portable PID in the field. The boring log also indicates that pure product was observed at this depth.

Soil samples from a depth interval of 12 to 14 feet (as noted on log) were submitted to both the field laboratory and an off-site analytical laboratory for chemical analyses. The field laboratory analyses of soil from boring B-8 contained high concentrations of TCE (6.2 milligrams per kilogram [mg/kg]) and TPH-diesel-range organics (DRO) (19,000 mg/kg). However, the off-site laboratory analyses reported a much lower TCE concentration of 130 micrograms per kilogram (µg/kg), which is equivalent to 0.130 mg/kg.

During the same investigation, free product was observed at depths of four to seven feet in boring B-15 in the dirt access road near the Petroleum Hydrocarbon Area (PHA). A VOC reading of 9,300 parts per million was recorded for soil at six feet below grade, which is the location of

the groundwater table. This was presumably petroleum-related product of light non-aqueous phase liquid (LNAPL). A sample from 4–7 feet (indicated on the log, but the table shows 7-10 feet) was collected for chemical analyses. TCE was detected at 140 µg/kg and xylenes were detected at 13,000 µg/kg (13 mg/kg). At test pit N4, north of Pond 1 and excavated in 2008, a greenish-black liquid was reported to have oozed from the ground after the test pit was backfilled. The liquid had a very strong odor similar to nail polish remover (i.e., solvent odor) and the PID recorded a total VOC reading of more than 700 parts per million volume (ppmv).

As part of the 2002 study (Tetra Tech, 2002), grab groundwater samples from temporary wells were inspected for free product in accordance with MDE's request in a letter dated August 15, 2001. The 2002 report does not mention observing any free product in the samples. In the past, oil-water-interface probes used to screen for free product have not been used at the site. When interviewed, several Tetra Tech, Inc. (Tetra Tech) geologists that recently installed and sampled wells at the DRA stated that no DNAPLs had been observed during site investigations. Therefore, although LNAPLs may have been observed at several locations mentioned above, visual observations were not used as a line of evidence to confirm the presence of DNAPLs in this study.

3.4.1.2 Chemical Concentrations in Soil above DNAPL Saturation Threshold

Soil sampling results can be compared to a DNAPL saturation-threshold concentration. This is the cVOC concentration at which, when exceeded in a soil sample, DNAPL would be expected in the soil. Chemical concentrations in soil above the threshold DNAPL saturation are evidence of DNAPL in the unsaturated zone. The threshold DNAPL-saturation in soil is typically assumed to be between five and 10% of soil pore-space. The chemical concentration in soil corresponding to threshold DNAPL saturation (C_D) can be estimated using the following equation (Kueper and Davies, 2009):

$$C_D = \frac{S_r \emptyset \rho_N 10^6}{\rho_h} + C^T$$

where:

 C_0 = threshold DNAPL soil-saturation concentration, in milligrams per kilogram (mg/kg)

 S_r = threshold DNAPL saturation (set between 0.05 and 0.10), the fraction of minimum soil pore space required to be occupied by the DNAPL-saturated product

 \emptyset = effective porosity (unitless), the porosity of the soil that can be occupied by a liquid

 ρ_{N} = DNAPL density, in grams per cubic centimeter (g/cm³)

 $\rho_b = \text{dry soil bulk density (g/cm}^3)$

 C^{T} = partitioning threshold concentration, the contaminant amount (mg/kg) in a soil sample in aqueous, vapor, and sorbed phases

For a TCE DNAPL, the threshold saturation concentration (C_D) equals 9,188mg/kg (or 9,188,000 µg/kg), using the following assumptions:

 $S_r = 0.05$

 $\emptyset = 0.25$

 $\rho_{N} = 1.47$

 $\rho_b = 2.0 \text{ g/cm}^3$

This ignores C^T , which is negligible compared to the DNAPL saturation term. A soil concentration greater than 9,188 mg/kg is considered conclusive evidence of DNAPL (Kueper and Davies, 2009).

3.4.1.3 Chemical Concentrations in Soil above the Partitioning Threshold

Soil sampling results can also be compared to a partitioning threshold concentration (C^T). This soil concentration is based on equilibrium partitioning relations of the cVOC in soil, air, and water, and is typically estimated using site-specific soil parameters, if available. A cVOC concentration above this concentration would only indicate the possible presence of DNAPL in the unsaturated or saturated zones (i.e., not conclusive evidence, compared to the saturation-threshold concentration discussed in Section 3.4.1.2). The chemical concentration in soil corresponding to the partitioning threshold can be estimated using the following equation (Kueper and Davies, 2009):

$$C^{T} = \frac{C_{t}}{\rho_{b}} (K_{d} \rho_{b} + \theta_{w} + H^{t} \theta_{\alpha})$$

where:

 C^{T} = soil concentration (mg/kg) threshold for a chemical

 C_i = effective solubility of chemical, in milligrams per liter (mg/L)

 $\rho_b = \text{dry soil bulk density (g/cm}^3)$

 K_d = soil water partition coefficient, in milliliters per gram (ml/g) $[K_d = K_{oc}f_{oc}]$

 θ_w = water filled porosity (unitless) from moisture content

H' = unitless Henry's Constant

 θ_a = air filled porosity (unitless)

 K_{oc} = organic carbon-water partition coefficient (ml/g)

 f_{oc} = fraction of organic carbon (unitless)

Assuming a TCE DNAPL with $C_i = 1,100 \text{ mg/L}$, $K_{oc} = 126 \text{ ml/g}$, and H' = 0.31 in a soil sample having $\theta_w = 0.15$, $\theta_a = 0.10$, $\rho_b = 2.0 \text{ g/cc}$, and $f_{oc} = 0.003$, the value of C^T would be 515 mg/kg (or 515,000 µg/kg). This C^T value is used in this study to evaluate soil samples for TCE DNAPL. For samples in the saturated zone, θ_a is zero and θ_w is 0.25. Therefore, C^T in the saturated zone is 553 mg/kg (or 553,000 µg/kg). This calculation requires knowledge of site-specific soil parameters and quantitative chemical analyses of the soil. Measured concentrations that only marginally exceed this concentration may be false positives, primarily because of uncertainty associated with estimating the soil-water partition coefficient (Kueper and Davies, 2009).

3.4.1.4 Site Use/Site History

USEPA studies indicate that DNAPLs are associated with specific types of industries, processes, and practices. Some industries, processes, and practices that typically use solvents are electronic manufacturing, dry cleaning, metal product manufacturing, engine manufacturing, metal machining, tool and die operations, and disposal of solvents in unlined pits. The DRA is one such unlined dump, historically used to dispose of debris and industrial wastes. Site activities at the time of full-scale operations included aircraft manufacturing and the confirmed use of TCE as a solvent. Various petroleum-based fuels, oils, and lubricants were also used at the facility to operate and maintain ground vehicles, aircraft, and machinery. Therefore, site history and use provide a positive line of evidence, in conjunction with other lines of evidence, that DNAPLs may be at the site.

3.4.1.5 Vapor Concentrations

The location of an unsaturated zone vapor plume may indicate the location of current or former DNAPL. Vapor plumes can be measured using active or passive soil-gas sampling techniques. Passive soil-gas sampling has been used at the DRA to guide the placement of soil borings, test

pits, and monitoring wells. MIPs have also been used at the site as a screening tool to guide placement of soil samples and monitoring wells. However, MIP results were not used for the DNAPL evaluation in this study because soil or groundwater samples were collected at locations where VOC contamination is indicated by MIP results. Soil and groundwater samples from MIP locations provide a more direct indication of DNAPL than the MIP readings; therefore, chemical analyses of soil and groundwater samples collected at MIP-indicated locations were used to assess the possible presence of DNAPL at the DRA. Vapor-sampling results alone were not used to evaluate DNAPLs because the vapor results were used to target other, more direct methods, such as MIPs and soil sampling, for chemical analyses.

3.4.2 Groundwater Methods

As discussed previously, using soil sampling results to evaluate for DNAPLs entails numerous difficulties and uncertainties. Therefore, groundwater methods typically offer better means of inferring DNAPL source areas. Groundwater samples generally represent water quality conditions over a larger area than does a soil sample. A groundwater sample at a particular point integrates conditions near the sampling location and, to a lesser extent, groundwater conditions hydraulically upgradient of the sampling location along its flow path. Therefore, groundwater data can be used to "trace" detected constituents back along a groundwater flow path.

3.4.2.1 Magnitude of Groundwater Concentrations

Solvent concentrations in groundwater samples in excess of 1% of the solvent's solubility typically indicate groundwater that may have contacted DNAPL. The water solubility of TCE can vary based on several factors. However, an effective solubility of TCE at 20° – 25° Celsius is generally accepted to be 1,100 milligrams per liter (mg/L), if TCE is assumed to be the only product in the DNAPL. Therefore, for TCE, the concentration at 1% effective solubility ($C_{i(1\%)}$) is 11 mg/L or 11,000 micrograms per liter (µg/L). A groundwater TCE concentration exceeding $C_{i(1\%)}$ (11 mg/L) indicates that the groundwater may have come into contact with DNAPL. Groundwater flowing past residual or pooled DNAPL will result in dissolved–phase plumes of VOCs. Above the water table, DNAPLs can lead to vapor plumes in the unsaturated zone.

For the groundwater evaluation, a method was used that also accounts for the TCE-daughter products *cis*-1,2-DCE and VC. This method provides a more conservative estimate of TCE concentrations and, therefore, possible DNAPL areas, than using the TCE results alone. The TCE

daughter product concentrations for *cis*-1,2-DCE and VC were converted to equivalent TCE (TCE_{EQ})-product concentrations by converting the *cis*-1,2-DCE and VC mass per volume (mass/volume) concentrations to moles per volume and then converting the parent concentration to mass/volume. This method assumes that biodegradation has not progressed much beyond VC.

The TCE_{EQ} groundwater concentrations of TCE, *cis*-1,2-DCE, and VC were computed using molecular weights of 131.5, 97.0, and 62.5 grams/mole for these compounds, respectively. The equivalent total concentration of TCE_{EQ} was estimated assuming that each mole of *cis*-1,2-DCE and VC derives from one mole of TCE. In areas of high TCE_{EQ} (i.e., that exceed the $C_{i(1\%)}$) where relative TCE concentrations are low, the TCE_{EQ} would be primarily derived from *cis*-1,2-DCE and VC. In these cases, the TCE_{EQ} concentration likely represents a possible DNAPL upgradient of the location of the computed TCE_{EQ}.

A lack of TCE in these areas would indicate that the plume has degraded as it moved away from the source area to the monitoring point that has a high TCE_{EQ} . Plots of TCE in groundwater are used to identify possible source areas, whereas TCE_{EQ} is used to identify possible upgradient sources that are not directly monitored. For BTEX, the combined BTEX concentration is used to evaluate the locations of possible source areas. The chemical data used for these analyses are in Section 4 and Appendix A.

3.4.2.2 Other Groundwater Methods

Other methods of evaluating DNAPLs in groundwater consist of evaluating for the factors listed below. If applicable, the methods mentioned in this section are noted and briefly discussed in the evaluation of individual source areas presented in Section 4.

- a persistent plume
- increasing groundwater concentrations with depth
- contamination in apparently anomalous locations
- evaluation of groundwaterconcentration trends with time
- the use of partitioning inter-well tracer tests and MIPs

Section 4

Source Areas' Nature and Extent

As discussed in Section 2, the Dump Road Area (DRA) investigation area was initially identified in the 1989 preliminary assessment (PA) as possible acid pits and was later investigated in 1991 after the Maryland Aviation Administration (MAA) encountered four drums adjacent to Taxiway Tango during trenching to install an electrical cable. Preliminary investigations from 1992-1996 and follow-on work to date have identified soil and groundwater contaminant source areas through geophysical surveys, soil-gas surveys, trenches, test pits, membrane interface probe (MIP) screening, soil borings, soil sample analyses, and groundwater sampling and analyses. These investigations identified a large area of soil fill and debris east of Taxiway Tango, extending to the base of the embankment at Frog Mortar Creek. Investigation of this fill area identified geophysical electromagnetic (EM) anomalies and areas containing buried debris, soil containing volatile organic compounds (VOCs), and soil containing other soil contaminants (such as polycyclic aromatic hydrocarbons [PAHs]) and metals from past dumping and backfilling. Past dumping and backfilling has led to VOCs remaining in soil and pond sediment at the DRA, and the development of large contaminant plumes of VOCs in groundwater in the upper, intermediate, and deep portions of the surficial aquifer east of Taxiway Tango and extending to Frog Mortar Creek.

4.1 DUMP ROAD AREA FILL CHARACTERISTICS

Several events indicate that fill, debris, and wastes were placed in the area of the DRA. During the 1989 PA of the airport, the MSA facility manger stated that former aircraft facility employees had told him that spent battery acid, acid-type strippers, and other acidic solutions were routinely dumped into three ponds or "acid pits" east of Taxiway Tango. The former aircraft facility employees also told the MSA facility manager that dredge spoils and construction debris had been disposed of in these ponds. No follow-up work was conducted at the acid pits as part of the PA.

In July 1991, four drums were uncovered during installation of underground electric cables immediately west of Taxiway Tango. A subsequent file review in 1991 produced a 1956 U.S. Army Corps of Engineers map and soil profiles that indicated an area of fill and trash approximately 900 feet long and five feet deep underlying Taxiway Tango west of the ponds. This discovery prompted MAA to conduct a geophysical survey of a 200- by 1,600-foot area adjacent to Taxiway Tango between the taxiway and the runway.

Numerous geophysical anomalies were detected indicating possible buried metal within the survey area. This area became known as the Taxiway Tango Median Anomaly Area (TT Median Area) because of these anomalies. The top surfaces of the metal were estimated to be at shallow depths of 2–3 feet below grade. During a 1996 environmental investigation of the DRA, several drums were uncovered in the forested area near wells MW-2 and MW-5 northeast of Taxiway Tango. These events indicate that fill, debris, and waste are possibly in the subsurface at the DRA.

In 2000, trenches and two test pits were excavated in the TT Median Area and Drum Area (DA) of the DRA (Tetra Tech, 2000). Debris types were noted in the field and fill depths and thicknesses were determined for each test pit and trench. Later, a 2007 geophysical survey of the TT Median Area and the area east of Taxiway Tango identified EM anomalies suspected of containing conductive metallic/magnetic objects in the subsurface. These anomalous areas were investigated via test pits A1 through A44 in 2008–2009 to confirm the geophysical investigation findings, to evaluate fill depth, and assess any buried materials.

The 2007 geophysical survey and follow-on test-pit investigation delineated several geophysical anomaly areas at the DRA. The geophysical survey results indicate contiguous areas of fill and buried debris suspected of containing waste. These were designated Areas 1–10, which are shown in Figures 4-1 and 4-2. The fill/debris thicknesses and fill/debris maximum depths of the test pits and trenches were also plotted and contoured in these figures.

At several test pit locations, the excavation could not be advanced beneath the fill due to the groundwater or equipment limitations. Therefore, fill and debris may extend beneath the test pit depths indicated in Figure 4-2. However, their delineation provides a framework for estimating fill/debris volumes and evaluating potential remedial alternatives. They also provide a basis for discussing the test pit results in this section. The EM anomaly areas range in size from 0.18 acres

for Area 3 to 5.10 acres for Area 2. The site also has non-anomalous EM areas where the geophysical survey results do not indicate buried metal or debris.

Using inferences for areas inaccessible during the surveys (the areas of Ponds 1 and 2, and the area east of these ponds), landfill debris is estimated present across approximately 25 acres at MSA. The following sections summarize the results of the EM survey and test pit program for these 10 areas. These summaries were taken from the RI report (Tetra Tech, Inc. [Tetra Tech], 2012a); details of the fill and debris depths and thicknesses therein are incorporated using the contoured fill-depth and thickness data in Figures 4-1 and 4-2.

4.1.1 Area 1

Area 1 is a small 0.20-acre area in the northwestern portion of the site with a single test pit (N1). The geophysical survey in-phase instrument response in this area was weak; it only slightly indicated the possible presence of buried metal. The terrain-conductivity survey indicated no buried material. It was therefore considered a non-anomalous area for test pit purposes. No significant fill, debris, or elevated VOC readings (using a portable PID) were found at test pit N1.

4.1.2 Area 2

Area 2, in the northern portion of the site, includes Pond 2 to the east and extends past Taxiway Tango to the west. This area includes test-pit excavations TT-EX-1, A1, A2, A14, A15, A24, A25, A34, and A36. Test pits A26, A35, and A42 are immediately south, north, and east, respectively, of the Area 2 boundaries. Except for A34 and A35, test pits near Area 2 uncovered debris mixtures containing metal and wood scraps, glass fragments, batteries, concrete, and 55-gallon drums. The thickness of this fill ranges from 1.4- to nine-feet thick (at A2 and excavation TT-EX1, respectively), and has a maximum bottom depth of 10 feet below grade at A1 and A14. Elevated field measurements of VOCs in soil range from 1.2 parts per million per volume (ppmv) at A26 to greater than 2,000 ppmv (jar head-space analysis) at excavation TT-EX1.

4.1.3 Area 3

Area 3 is in the western portion of the site, between Taxiway Tango and the runway. Two test pits (A23 and excavation TT-EX6) were excavated in this area. The test-pit excavations indicate fill from the ground surface to depths of four to five feet below grade. Fill thickness also ranges from four to five feet. Observations of petroleum staining, odors, and VOC field-readings of

62.3 to 350 ppmv were reported for this area. Debris observed in the test pits includes rebar, transformer fuses, electronic tubes, scrap metal, and what was apparently a drum.

4.1.4 Area 4

Area 4 is in the west—central portion of the site, with Pond 1 on the eastern boundary and the grass median between Taxiway Tango and the runway as the western boundary. Ten test pits (excavations TT-EX2, A3, A4, A8, A9, A21, A22, A27, A28, and A33) were excavated in Area 4. Fill thickness ranges from zero at A9 to eight feet at A27, below grade (the maximum bottom depth in this area). Materials found in this area include drums, creosote stains, scrap metal, wood, and a white crystalline material. Black-stained soil, odors, and elevated field-readings of VOCs were also observed at these test pits, ranging from 1.1 at A28 to greater than 1,000 ppmv at excavation TT-EX2.

4.1.5 Area 5

Area 5 is a large (4.02-acre) area in the southeastern portion of the site. It extends from the southern edge of Area 2 to the heavily wooded area along the southern border. Eleven test pits (DA trenches, A5, A6, A10, A11, A12, A38 through A41, and A43) were excavated in this area. Fill and debris were observed in all test pits in this area. Fill thickness ranges from five feet at A11 to 10 feet at A38 and A41 (at the Area 5 western and eastern boundaries, respectively). Fill and debris were typically encountered at the ground surface and were reported at maximum bottom depths of 11 feet below grade at A6 and A12, along the longitudinal axis of Area 5. Materials found include 55-gallon drums, metal scraps, glass, burned materials, plastic, wood, and vehicle parts.

4.1.6 Areas 6 and 7

Areas 6 and 7 combined comprise approximately one acre of land southwest of the southern portion of Area 5, between Area 5 and Taxiway Tango. Six test pits (A7, A13, and A29 through A32) were excavated in this area. A29 is outside of Areas 6 and 7, but was excavated to assess low EM readings near these two areas. A29 contained apparent fill from the ground surface to a depth of two feet; however, no debris was observed at this location. Significant fill and debris were not observed in other test pits in this area.

4.1.7 Area 8

Area 8 is in the southwestern part of the site. Six test pits (excavations TT-EX-3 through TT-EX5, and A18 through A20) were excavated in this area. Fill was observed in all six test pits and debris was encountered in four. Fill thicknesses range from four feet at excavation TT-EX5 to seven feet at TT-EX3 and TT-EX4. The maximum fill depth is seven feet below grade at both TT-EX3 and TT-EX4. Fill includes black discolored soils, acute odors, and elevated field readings of VOCs ranging from less than 100 ppmv at TT-EX4 to greater than 2,000 ppmv at TT-EX3. Items reported in these test pits include a 30-gallon drum, rebar, glass, concrete, scrap metal, wood, and brick.

4.1.8 Area 9

Area 9 is a 2.07-acre area in the northeastern portion of the site. It is a densely vegetated area outside the MSA security fence and bordering Frog Mortar Creek, where geophysical surveying could not be conducted due to steep terrain and dense vegetation. Three test pits (A16, A17, and A44) were excavated in this area to determine the presence, thickness, and depth of possible fill and buried debris. Fill was encountered from the ground surface to three and 4.5 feet below grade at A17 and A44, respectively. Debris encountered at A17 includes glass, plastic, wood, and Styrofoam[®]. Fill was not encountered at A16, although a black sludge-like soil and a strong odor of what was described as paint thinner was found at eight to 10 feet below grade. Concrete rubble was observed in A44 at a depth of 4.5 feet.

4.1.9 Area 10

Area 10 is east of Area 4 in the heavily wooded area near Pond 1. Two test pits (N5 and A37) were excavated in this area. Fill and debris were observed in A37 but not in N5. Fill thickness is five feet at A37, where the depth below grade is also five feet. Debris encountered in this pit includes glass and wood.

4.1.10 Non-Anomalous Areas

Test pits N2, N3, N4, N6, N7, and N8 were excavated in non-anomalous areas outside of Areas 1 through 10. Test pit N1 was excavated in Area 1, which only had a very weak EM signal; N5 was in a portion of Area 10 where geophysical surveying could not be performed. N2 and N3 are in a large, non-anomalous area in the northern portion of the site north of Area 2. No significant fill,

debris, or elevated VOC readings were found at test pits N2 or N3. At N3, 0.1 foot of fill was found at a depth of 3.9 feet below grade. The fill material at N4 (north of Pond 1) is three feet thick and contained a greenish-black liquid and an odor that provided a field reading for VOC of 700 ppmv. Debris encountered in this pit includes glass and wood.

Test pits N6 and N7 are in the southwestern portion of the site. They are in non-anomalous areas west of Area 5, outside of Areas 6 and 7, and east of Taxiway Tango. No significant fill, debris, or elevated VOC readings were found at these test pits.

At test pit N8, southeast of the Area 5 boundary, seven feet of fill was encountered from the ground surface to seven feet below grade. Debris found at N8 includes fiberglass mesh, glass, metal pieces, piping, and concrete rubble. The low geophysical survey response for this area is likely the result of the relatively small quantity of metal debris encountered here.

4.2 SOIL AND GROUNDWATER CONTAMINANT SOURCES

Previous investigations have identified four primary contaminant source areas for trichloroethene (TCE) and benzene, toluene, ethylbenzene, and xylenes (BTEX):

- Taxiway Tango Median Area (TT Median Area)
- Drum Area (DA)

Ponds 1 and 2

• Petroleum Hydrocarbon Area (PHA)

These four areas are described in Section 2. The present review of existing data confirms all but Pond 2 as primary source areas for DRA soil and groundwater contamination. Results of shallow sediment samples from Pond 2 do not indicate Pond 2 as a source for VOCs at the DRA. However, additional shallow sediment samples and deeper sediment samples will need to be collected from Pond 2 before it can be removed from consideration as a possible source area.

These four source areas have been the focus of the initial investigations conducted in the 1990s and the follow-on work conducted to date. However, recent field investigations indicate additional areas of elevated VOC soil and groundwater contamination have been identified. Therefore, available data collected from the larger area of fill defined by the geophysical survey and test pit excavations were also evaluated to assess the extent of soil, groundwater, surface water, and sediment contamination beyond the previously identified source areas, and to

determine if additional possible source areas exist. The extent of contamination in various environmental media deriving from these possible source areas and their surrounding areas are discussed in the next section.

4.2.1 TCE Source Areas and DNAPL Assessments

Figures 4-3 through 4-5 are contour maps of TCE in soil, displayed by three soil-depth categories: surface soil (zero to two feet), shallow subsurface soil (between two to 15 feet), and deep subsurface soil (greater than 15 feet deep). Figure 4-3 also includes the TCE results for the shallow sediment samples collected from Ponds 1 and 2. Figures 4-6 through 4-11 are maps of TCE_{EQ} and TCE concentrations and groundwater potentiometric surfaces (i.e., groundwater flow potential) for the upper, intermediate, and lower surficial aquifer zones, respectively. In the figures, horizontal groundwater flow is assumed perpendicular to the blue groundwater-elevation contour lines. Vertical or downward/upward groundwater flow can also occur, but it is considered secondary to horizontal groundwater flow.

At the DRA, groundwater in the surficial aquifer generally flows from southwest (airport runway area) to northeast toward Frog Mortar Creek. Within the DRA there may be areas where local groundwater flow deviates from the overall southwest–northeast trend due to variations in geologic materials, permeabilities, and recharge. Figure 4-12 shows the locations of hydrogeologic cross-sections developed for this study. Figure 4-13 is a hydrogeologic cross-section through the TT Median Area, the PHA, Pond 1, and east of Pond 1 to Frog Mortar Creek. Figure 4-14 is a hydrogeologic cross-section through the DA and a thick fill area near well cluster DMW-5S/I/D. These figures are referenced in the discussion that follows. Table 4-1 shows the groundwater VOC data used for this evaluation. Figures 4-3 through 4-11 show elevated concentrations of TCE in surface soil/sediment, subsurface soil, and/or groundwater in the following five areas:

Area	Affected media		
Petroleum Hydrocarbon Area, Pond 1	surface sediment/subsurface soil, groundwater		
TT Median Area	subsurface soil, groundwater		
Drum Area	surface and subsurface soil, groundwater		
Taxiway Tango Area—North	subsurface soil		
Area East of Pond 1	subsurface soil, groundwater		

A summary of each area with elevated TCE concentrations is described below.

4.2.1.1 PHA and Pond 1

This area consists of highly elevated TCE concentrations in the Pond 1 shallow sediments (Figure 4-3) and the intermediate subsurface soil at the Petroleum Hydrocarbon Area (PHA). Sediment samples from Pond 1 contain the highest levels of TCE in sediment or soil at the DRA, with elevated TCE concentrations ranging from 69,000 μ g/kg at sampling EP1-SD2, to 270,000 μ g/kg at EP1-SD5. A low concentration of TCE (11 μ g/kg for EP1-SD4) was detected in one other sample from Pond 1; the three remaining samples are non-detects. The TCE concentration of 270,000 μ g/kg in sample EP1-SD5 is approximately 50% of TCE's saturated (i.e., wet sample) DNAPL saturation threshold concentration (C^T = 553,000 μ g/kg). Although this sample's TCE concentration does not exceed the C^T , it is within the same order of magnitude, which indicates that TCE DNAPL may be in the Pond 1 sediment, either in unsampled areas of the pond, or in deeper sediments below where samples EP1-SD5 and EP1-SD2 were collected.

Samples from Pond 1 were last collected in 2005, and the concentrations used for this evaluation may not represent current conditions. Although sampling results indicate localized areas of elevated TCE in Pond 1 sediment, additional samples are required to fully delineate the extent of this possible TCE source area. Further, samples have not been collected at depth in Pond 1 sediment; therefore, the vertical extent of the elevated TCE is not known for any portion of Pond 1. At present, the hydraulic connection between Pond 1 and groundwater has not been determined. However, a study is planned to assess the interconnection between the Pond 1 and shallow groundwater.

The PHA is northwest of and adjacent to Pond 1; in this area, TCE was detected either at low concentrations in surface soil, or not at all (Figure 4-3). Therefore, surface soil at the PHA does not appear to represent a TCE source. However, TCE was detected at elevated concentrations in shallow subsurface soil (Figure 4-4) at depths of four feet (2,000 µg/kg at PHA-SB4-4, and 420 µg/kg at PHA-SB1-4), nine feet (4,000 µg/kg at PHA-SB3-9), and 12 feet (2,000 µg/kg at PHA-SB2-12). As shown in Figure 4-5, TCE was not detected in deep subsurface soil samples at depths of 16 and 20 feet in boring DR-SB-7, at a 19-foot depth at DR-SB-17, or at 24 feet in boring DR-SB-10.

Figure 4-6 shows a TCE_{EQ} concentration of 54,930 μ g/L in groundwater at well DMW-9S. This concentration exceeds the groundwater TCE DNAPL threshold ($C_{i(1\%)}$) of 11,000 μ g/L, which indicates that TCE DNAPL may be in the upper surficial aquifer in the PHA area. However, much of the elevated TCE_{EQ} for DMW-9S is due to high concentrations of *cis*-1,2-DCE (12,000 μ g/L and VC (18,000 μ g/L). TCE at DMW-9S is 790 μ g/L (Figure 4-7), which is less than the 11,000 μ g/L DNAPL threshold for groundwater. This therefore suggests that the possible DNAPL source in this area may be hydraulically upgradient of (i.e., west of) DMW-9S.

As shown in Figures 4-8 through 4-11, wells DMW-9I and DMW-9D have TCE_{EQ} concentrations of 4,887 and 3,405 μg/L, respectively, and TCE concentrations of 700 and 2,800 μg/L, respectively, indicating that DNAPL is not likely at those locations and depths; therefore, DNAPL is likely restricted to the upper surficial aquifer upgradient and west of the well DMW-9S area. As shown in Figures 4-10 and 4-11, concentrations of TCE_{EQ} and TCE at DMW-9D, MW-20D, MW-26D, DMW-18D, DMW-3D, and DMW-2B do not indicate DNAPL in the lower surficial aquifer at the PHA, Pond 1 area, and area east of Pond 1. The TCE_{EQ} concentrations for the PHA and Pond 1 are shown in cross-section in Figure 4-13. The cross-section shows residual concentrations of TCE in the unsaturated and saturated zones in the PHA, and a high concentration of TCE in Pond 1 sediment.

Of all the soil and sediment sampling results for this area, the TCE concentration detected in Pond 1 sediment is the only one that indicates the possible presence of DNAPLs. As described above, the TCE_{EQ} concentration in groundwater at well DMW-9S (54,930 µg/L) exceeds the TCE $C_{i(1\%)}$ of 11,000 µg/L, thus indicating the possible presence of DNAPL in the area upgradient or west of DMW-9S. Concentrations indicative of DNAPL have not been detected in the deeper

wells DMW-9I and DMW-9D, or in the surrounding wells MW-4, DMW-10S/I, MW-39S, and MW-20S/I/D (see Figures 4-6 through 4-8).

4.2.1.2 <u>Taxiway Tango Median Anomaly Area</u>

The TT Median Area is the open grass area that runs parallel to and between the airport runway on the west and Taxiway Tango to the east. It also includes areas underneath the taxiway and runway and areas west of the runway (Figure 4-3). As shown in Figure 4-3, TCE was either not detected (e.g., samples DR-SB-32-02, DR-SB-34-02, TT-EX3-T15D-2) or was detected at low concentrations in surface soil (e.g., DR-SB-3-SS) in this area. Therefore, the surface soil at the TT Median Area does not appear to represent a TCE source. However, TCE was detected at elevated concentrations in the shallow subsurface soil (Figure 4-4) at depths of 10 feet (7,680 μg/kg at MIP-58-SS-10), six feet (1,200 μg/kg at DR-A23), and four feet (550 μg/kg at TT-EX2-T11A-4). As shown in Figure 4-5, two deep subsurface soil samples contained elevated TCE concentrations at 18 feet (4,240 μg/kg at MIP-58-SS-18) and 20 feet (315 μg/kg at MIP-61-SS-20) in this area. Concentrations in these samples indicate only residual (i.e., sorbed) TCE contamination in soil and do not indicate TCE DNAPL (i.e., free product).

Figure 4-6 shows well DMW-11S, screened in the upper surficial aquifer in the TT Median Area, with a TCE_{EQ} groundwater concentration of 52,648 μ g/L (TCE concentration of 12,000 μ g/L in Figure 4-7). These TCE_{EQ} and TCE concentrations exceed the TCE $C_{i(1\%)}$ of 11,000 μ g/L, which indicates that TCE DNAPL is likely here. Although the TCE_{EQ} concentration is low at MW-3 (18 μ g/L), TT-4 has a TCE_{EQ} of 17,259 μ g/L (depth of 13 feet) resulting from a high VC concentration of 2,700 μ g/L and a lower cis-1,2-DCE concentration of 470 μ g/L (TCE was not detected at TT-4).

Groundwater samples collected at MIP-58 at a 9–11 foot depth and MIP-61 at a 13–15 foot depth have TCE_{EQ} concentrations above 11,000 μ g/L, indicating that possible DNAPL in the upper surficial aquifer groundwater extends several hundred feet southeastward in the TT Median Area from DMW-11S to MIP-58 and MIP-61. However, TCE concentrations for these samples (Figure 4-7) are 3,610 μ g/L (MIP-58) and 3,630 μ g/L (MIP-61), and large proportions of the high TCE_{EQ} are the result of high concentrations of *cis*-1,2-DCE and VC. The high *cis*-1,2-DCE and VC concentrations suggest that a TCE source area is likely upgradient or southwest (toward the runway) in this area.

As shown in Figures 4-6 through 4-11, surrounding wells MW-38S, MW-37S, MW-25S/I, MW-26S/I/D, DMW-10S/I, MW-3, DMW-22I/D, DMW-1S, and MW-21I/D have TCE_{EQ} concentrations well below the threshold level of 11,000 μ g/L. These results indicate that DNAPL is likely restricted to the upper clay-rich portion of the surficial aquifer in the area of well DMW-11S and possibly in areas southwest of MIP-58 and MIP-61. Southeast of DMW-11S, groundwater TCE_{EQ} concentrations of 266,468 μ g/L at PA-7 (15 feet deep), 87,375 μ g/L at MIP-30 (31–33 feet deep), 58,006 μ g/L at MIP-26 (44–46 feet deep), and 16,893 μ g/L at well DMW-1A indicate the possibility of DNAPLs in this area.

TCE concentrations (Figure 4-7) exceeded the 11,000 μg/L TCE threshold at PA-7 (220,000 μg/L) and MIP-30 (13,000 μg/L; Figure 4-9), TCE at MIP-26 (44–46 feet deep; Figure 4-9) is slightly less than the threshold at 8,000 μg/L. PA-7 is in the upper surficial aquifer at a depth of 15 feet, and the samples with high TCE concentrations at MIP-30 (31–33 feet deep), MIP-26 (44-46 feet deep), and DMW-1A are from the intermediate surficial aquifer zone at depths of 31-46 feet (MIP-30 and MIP-26) below grade and 45 to 55 feet below grade at DMW-1A. The results for surrounding wells DMW-1B (screened below DMW-1A), MW-23S/I/D, DMW-1S, MW-21I/D, DMW-8S/I/D, MW-2, and MW-19I/D indicate that the TCE DNAPL area is localized near PA-7 and MIP-30. TCE results for the lower surficial aquifer zone (Figure 4-11) do not indicate the likely presence of DNAPL in this zone.

TCE concentrations for the TT Median Area are shown in cross-section in Figure 4-14. As shown in Figure 4-14, residual concentrations of TCE were detected in unsaturated-zone soil at test pit DR-A-23. However, the higher concentrations of TCE detected in soil in the TT Median Area are south and north of well DMW-11S, where a high TCE_{EQ} concentration in groundwater (52,648 μ g/L) has been detected.

Soil concentrations of TCE at the TT Median Area do not indicate DNAPL in soil. However, the TCE_{EQ} concentration of 52,648 µg/L and TCE concentration of 13,000 µg/L at well DMW-11S exceed the TCE $C_{i(1\%)}$ of 11,000 µg/L, indicating the possible presence of DNAPL in this area. Concentrations indicative of DNAPL are not indicated in the deeper well DMW-11I or in the surrounding wells at cluster MW-38S, MW-37S, MW-3, and DMW-22I/D (not shown on the cross-section).

The more than 20 feet of clay in the DMW-11S area probably limits the elevated level of TCE detected in groundwater at this location to the immediate vicinity of this well. Permeability tests (i.e., slug tests) on wells DMW-11S and DMW-11I show low hydraulic conductivities ranging from 0.50 feet per day (ft/day) at DMW-11S to 0.90 ft/day at DMW-11I. Although the wells were screened in both silty-clay and sand, the test results primarily reflect the response of the sand layers. Therefore, the silty-clay underlying DMW-11S is expected to have a substantially lower permeability than indicated by these wells.

4.2.1.3 **Drum Area**

The Drum Area (DA) is in the southern portion of the DRA, east of Taxiway Tango (Figure 4-3). A group of deteriorated drums was discovered at this location in 1996 during preliminary environmental investigations at the DRA. Trenches were subsequently excavated and soil samples were collected for chemical analyses. The drums were discovered at the surface, so any possible soil contamination is likely to have occurred through leaking, spilling, or direct disposal to the ground. Fill Area 5, east of the DA between wells DMW-7S/I/D and DMW-5S/I/D (see Section 4.1.5 and Figures 4-1 and 4-2), is a large, northwest—southeast trending fill area where up to 11 feet of fill and debris were encountered in test pit excavations. Materials found there include 55-gallon drums, metal scraps, glass, burned materials, plastic, wood, and vehicle parts.

As shown in Figure 4-3, elevated TCE concentrations in DA surface soil samples range from 1,900 to 7,000 μ g/kg. The higher concentrations of TCE follow a northwest–southeast linear path running along sampling locations DA-NC-4-1 (6,500 μ g/kg), DA-T2-1-2 (7,000 μ g/kg), DA-T2-2-2 (7,000 μ g/kg), DA-T2-3-2 (5,100 μ g/kg), and DA-T4-3-2 (5,900 μ g/kg). These concentrations are nearly two orders of magnitude less than the soil TCE C^T concentration of 553,000 μ g/kg. Therefore, these soil sampling results do not indicate DNAPL, but instead indicate sorbed TCE in the soil. However, these elevated concentrations may still be a continuing source of TCE contamination in soil and groundwater in the DA. The extent of the elevated levels of TCE in the surface soil here have not yet been delineated, particularly in areas northwest, north, east, and southeast of the sampled area.

Shallow subsurface soil samples (Figure 4-4) show sorbed TCE at depth, but at lower concentrations than in the surface soil samples. The higher concentrations of TCE in the DA shallow subsurface soil range from 1,500 μ g/kg (test pit DR-A39) to a maximum of 2,200 μ g/kg

in DR-SB14-15 (15 foot depth) near wells DMW7S/I/D. This area has fewer shallow subsurface-soil sampling locations than surface soil sampling locations, but the results indicate that TCE in the shallow subsurface soil has approximately the same footprint as the surface soil sampling locations. South of wells DMW-7S/I/D, at MIP-55-SS-35 (Figure 4-5), TCE was detected at a concentration of 865 μ g/kg at 35 feet deep. However, in deep subsurface soil north of wells DMW-7S/I/D, TCE concentrations are 25 μ g/kg or less. Deep subsurface soil samples with depths greater than 15 feet have not been collected below the DA trench samples.

Figure 4-6 shows TCE_{EQ} concentrations exceeding the TCE $C_{i(1\%)}$ of 11,000 µg/L in the upper surficial aquifer at DA-1, DA-3 through DA-9, DA-12, DA-13, MIP-28, and DMW-7S. The maximum TCE_{EQ} concentration for these samples in groundwater at the DA was detected in DA-7 (191,384 µg/L), a groundwater sample collected from 26 feet below grade east of the DA trenches and excavation. At DA-7, TCE was detected in groundwater (Figure 4-7) at a concentration of 130,000 µg/L. Additionally, TCE was detected in groundwater (Figure 4-7) at concentrations greater than 11,000 µg/L at DA-8 (70,000 µg/L), MIP-28 (68,600 µg/L), DA-4 (64,000 µg/L), DA-5 (58,000 µg/L), DA-3 (48,000 µg/L), DA-6 (33,000 µg/L), and DA-1 (12,000 µg/L). DA-1 through DA-14 were collected at depths ranging from 15 feet at DA-2 to 28 feet at DA-5, DA-8, DA-10, DA-11, and DA-14. The sample from MIP-28 was collected from 34 to 36 feet below grade. Although the TCE_{EQ} concentrations for DMW-7S and DA-9 exceeded 11,000 µg/L, the TCE concentrations of 8,050 µg/L at DMW-7S and 7,300 µg/L at DA-9 are less than 11,000 µg/L. Well DMW-7S is screened at 19 to 29 feet below grade (well DMW-7I is screened at 44 to 54 feet below grade).

TCE concentrations recorded before 2005 at DMW-7S and before 2004 at MW-5 consistently exceeded $11,000 \,\mu g/L$. These prior results support the possible presence of DNAPL in groundwater at the DA. DA sampling results indicate that DNAPL in the upper surficial aquifer groundwater likely extends from the DA trench area west of sampling location DA-1 to several hundred feet northeast between DA-6 and DA-9.

As shown in Figures 4-6 through 4-8, surrounding wells MW-2, MW-19S/I, DMW-8S/I/D, DMW-5I/D, DMW-6S/I/D, and MW32S/I exhibit TCE_{EQ} concentrations well below the TCE groundwater threshold-concentration. However, northwest of DMW-7S, at well DMW-5S, a TCE_{EQ} concentration of 11,336 μ g/L also indicates the possible presence of DNAPLs.

Groundwater sampling results indicate that DNAPLs may be extensive in the upper surficial aquifer, but that they are likely restricted to the upper portion of the surficial aquifer in this area.

The DA and associated TCE soil and TCE_{EQ} groundwater concentrations are shown in cross-section in Figure 4-14. The cross-section shows residual concentrations of TCE in the unsaturated zone at the DA, south of well DMW-7S. However, TCE_{EQ} (and TCE) groundwater concentrations southwest and northeast of well DMW-7S indicate possible DNAPL in this area.

The TCE_{EQ} concentrations for DA-12, MIP-41, and DMW-5S, northeast and hydraulically downgradient of the DA, exceed the TCE $C_{i(1\%)}$ concentration of 11,000 µg/L. However, the TCE concentrations of 2,300 µg/L at DA-12, 8,780 µg/L at MIP-41 (24 to 26 feet), and 9,300 µg/L at DMW-5S (Figure 4-7) do not support the presence of DNAPL. Concentrations of TCE slightly less than the 11,000 µg/L threshold at MIP-41 (24–26 feet) and DMW-5S suggest additional sampling is required in these areas to further assess the presence of DNAPL.

As shown in Figure 4-14, wells DMW-7S and DMW-5S appear hydraulically connected via a three- to six-foot thick sand layer at the base of both wells. The sand layer at both well locations is underlain by 2.5 to nine feet of clay, which would be expected to attenuate the downward movement of TCE to the intermediate and lower surficial aquifer zones. This is confirmed by the substantially lower TCE_{EQ} and TCE groundwater concentrations found at DMW-7I/D, DMW-5I/D, and MIP-41 (39–41 foot depth) (see Figures 4-8 through 4-11).

4.2.1.4 Taxiway Tango Area—North

Soil samples were collected in the northwestern area of the DRA (e.g., DR-SB-26, DR-SB-27, DR-SB-28, etc.) during recent investigations (Figures 4-3 through 4-5). These samples were collected in response to TCE having been detected in newly installed wells in the area (MW-33S and MW-34S/I), and from positive detections in soil gas samples collected in 2010. TCE was detected in this area in only one surface soil sample (DR-SB-29-02), at a trace concentration of 12 μg/kg (see Figure 4-3). As shown in Figure 4-4, TCE was detected at a concentration of 11,000 μg/kg in soil at a depth of 10 feet in sample DR-SB-27-10 (see northwestern contours in Figure 4-4) and at 1,100 μg/kg at 14 feet deep at sampling location DR-SB31-14. TCE was not detected in surrounding soil samples collected at this depth (e.g., DR-SB-6-11, DR-SB-29-10, DR-SB-30-08, DR-SB-26, and DR-SB-28-10). Additionally, Figures 4-6 through 4-9 show low

groundwater TCE_{EQ} and TCE concentrations at surrounding wells MW-33S/I, MW-35S, and MW-36S, indicating that the lateral boundary of the TCE in this area is likely localized. These soil and groundwater concentrations do not indicate DNAPLs, but additional soil and groundwater samples at depth and near samples DR-SB-27-10 and SR-SB-31-14 are required to further delineate this area of elevated TCE concentrations detected in soil.

4.2.1.5 **East of Pond 1**

As shown in Figures 4-3 and 4-4, the results of the surface and shallow subsurface soil samples collected east of Pond 1 (DR-A37, DR-SB-21, PA-16, and N5) do not indicate a soil-based source of TCE east of Pond 1. In deep subsurface soil (20 feet deep) at this location (Figure 4-5), TCE was detected at a concentration of 2,500 μ g/kg at MIP-51-SS-20, approximately 200 feet east of Pond 1. The concentration of a sample collected at a 40-foot depth was substantially lower (3.7 μ g/kg). These two samples were collected in the saturated zone, and likely represent concentrations in groundwater rather than TCE sorbed to soil.

Farther east and hydraulically downgradient of well DMW-9S and Pond 1, several intermediate surficial aquifer wells have TCE_{EQ} and TCE concentrations exceeding the $C_{i(1\%)}$ of 11,000 µg/L (Figures 4-8 and 4-9), possibly indicating DNAPL in these areas, as follows: MW-18I (TCE_{EQ} of 14,067 µg/L), DMW-3I (TCE_{EQ} of 30,784 µg/L), and DMW-2A (TCE_{EQ} of 19,804 µg/L). TCE concentrations at these wells in 2011 (Figure 4-9) were 13,000 µg/L at DMW-2A, 12,000 µg/L at DMW-3I, and 11,000 at MW-18I µg/L, which meet or exceed the TCE $C_{i(1\%)}$ of 11,000 µg/L and indicate the possible presence of DNAPLs in these areas.

The groundwater elevation contours shown in these figures show that wells MW-18S/I, DMW-3S/I, and DMW-2S/A are hydraulically downgradient of the PHA, well DMW-9S, and Pond 1. Although PA-13 (28 feet deep), which is hydraulically downgradient of Pond 1, has a moderately high TCE_{EQ} concentration of 8,406 μ g/L in upper surficial-aquifer groundwater (Figure 4-6), TCE was not detected at this location (TCE detection limit was 500 μ g/L). TCE was detected only at low concentrations of 7–12 μ g/L at PA-12 and MW-39 east of Pond 1 (Figures 4-6 and 4-7).

Farther east at MIP-51, groundwater samples were collected at depths of 19 to 21 feet (upper surficial aquifer) and 39 to 41 feet (intermediate surficial aquifer). The TCE_{EO} concentrations for

these samples were $305 \,\mu g/L$ and $1,485 \,\mu g/L$ for the shallow and deeper samples, respectively. These PA, MIP, and MW sampling results do not support the presence of DNAPL in the upper surficial aquifer between Pond 1 and DMW-3S/I/D and DMW-2A. However, groundwater samples have not been collected in the intermediate and lower surficial aquifer zones directly east of Pond 1, where DNAPL or higher concentrations of VOCs in groundwater in this area would be expected.

The geology of the intermediate and lower surficial aquifer zone beneath well MW-39S, PA-12, and PA-13 has not been confirmed. Additional groundwater samples at depth are required to further evaluate groundwater quality in this area. The hydraulic connection between Pond 1 and groundwater must also be assessed to determine the potential transport of cVOCs from Pond 1 to groundwater.

4.2.2 BTEX Source Area Evaluation

Figures 4-15 through 4-17 are contour maps of BTEX in soil for the three soil depth categories of surface soil (zero to two feet), shallow subsurface soil (between two and 15 feet below ground surface), and deep subsurface soil (greater than 15 feet deep), respectively. Figure 4-15 also includes BTEX results for the shallow sediment samples collected from Ponds 1 and 2. Figures 4-18 through 4-20 are contour maps of BTEX groundwater concentrations and groundwater potentiometric surfaces (i.e., groundwater flow potential) for the upper, intermediate, and lower surficial aquifer zones, respectively. In these figures, horizontal groundwater flow is assumed perpendicular to the blue groundwater elevation contour lines. Figure 4-21 is a hydrogeologic cross-section through the TT Median Area, the PHA, Pond 1, and the area east of Pond 1. Figure 4-22 is a hydrogeologic cross-section through the DA and a thick fill area near well cluster DMW-5S/I/D. These figures are referenced in the following discussion.

Figures 4-15 through 4-17 show the following areas with elevated concentrations of BTEX in surface soil/sediment, subsurface soil, and groundwater:

Area	Affected media		
Petroleum Hydrocarbon Area, Pond 1	surface sediment/subsurface soil, groundwater		
TT Median Area	subsurface soil, groundwater		
Drum Area	• groundwater		

A brief summary of each area of elevated BTEX concentrations is described below.

4.2.2.1 PHA and Pond 1

Highly elevated BTEX concentrations were detected in Pond 1 shallow sediments (Figure 4-15) and in the intermediate subsurface soil (Figure 4-16) at the PHA. Sediment samples from Pond 1 contain the second highest levels of BTEX in sediment or soil at the DRA, with elevated BTEX concentrations ranging from 1,942 μ g/kg (EP1-SD4) to 467,115 μ g/kg (EP1-SD5). Three other sediment samples from Pond 1 contained low concentrations of BTEX (7.4 μ g/kg at EP1-SD6; 19.7 μ g/kg at EP1-SD4; and 403 μ g/kg at EP1-SD1).

Samples from Pond 1 were last collected in 2005; therefore, the concentrations listed here may not represent current conditions. Although these sampling results indicate localized areas of elevated BTEX in Pond 1 sediment, additional samples are required to fully delineate the extent of this BTEX in this possible source area. Additionally, samples have not been collected at depth in the Pond 1 sediment; therefore, the vertical extent of the elevated BTEX is not known in any portion of Pond 1.

The PHA is northwest and adjacent to Pond 1. BTEX was either not detected or was detected at low concentrations in surface soil at the PHA (Figure 4-15). Therefore, surface soil at the PHA does not appear to represent a BTEX source. However, BTEX was detected at elevated concentrations in numerous shallow subsurface soil samples (Figure 4-16) at depths of four feet $(200,380 \, \mu g/kg$ at PHA-SB4-4) to 12 feet $(100,200 \, \mu g/kg$ at DR-SB-2).

The highest reported concentration of BTEX at the PHA is 2,138,900 µg/kg, detected in a sample collected from six-feet deep in test pit DR-A33. Soil boring PHA-SB-1 (Figure 4-16) was advanced adjacent to the 1996 soil boring B-15, where free product had been observed at 4-7 feet and a field VOC reading of 9,300 parts per million had been recorded for soil at six feet below

grade. BTEX was detected at a concentration of 1,470 μ g/kg in sample PHA-SB-1-4 (Figure 4-16), collected at a depth of four feet adjacent to boring B-15. Many of the elevated BTEX concentrations are near the water table, including the DR-A33 sampling location. As shown in Figure 4-17, BTEX was detected at low concentrations ranging from 2.97 to 20.47 μ g/kg in deep subsurface soil samples (borings DR-SB-7 at 16 and 20 feet, boring DR-SB-17 at 19 feet, boring DR-SB-10 at 24 feet, and boring MIP-25 at 40 feet).

The highest concentrations of BTEX in groundwater at the PHA are in the upper surficial aquifer samples. Figure 4-18 shows an upper surficial aquifer BTEX groundwater concentration of 22,990 μg/L at well DMW-9S. Southwest of DMW-9S, BTEX was detected at concentrations of 43,520 μg/L at PA-1 (12 feet; primarily xylenes at 35,000 μg/L and toluene at 6,800 μg/L), 1,300 μg/L at TT-3 (14.5 feet; toluene only), and 8 μg/L at SB-13 (28 feet; benzene only). A moderately low BTEX concentration of 75.8 μg/L was detected southeast of DMW-9S and west of Pond 1 at MIP-25 (14 to 16 feet). BTEX was not detected southeast of the PHA at PA-3 (28 feet) and north of the PHA at well MW-4 (screened from three to 30 feet, and groundwater typically at seven to eight feet).

As shown in Figures 4-19 and 4-20, intermediate and deep wells DMW-9I and DMW-9D at the PHA have BTEX concentrations of 20 and 24 μg/L (respectively), indicating that high concentrations of BTEX are not present at depth near the apparent PHA source area. However, wells have not been installed at sampling location PA-1 (Figure 4-18), an upper surficial aquifer sample with the highest BTEX concentration of 43,520 μg/L in groundwater at the PHA. In surrounding wells (MW-4, MW-26S/I/D, DMW-10S/I, and DMW-20S/I/D), BTEX was either not detected or was detected at low concentrations ranging from two to 66.8 μg/L. Farther east and hydraulically downgradient of well DMW-9S and Pond 1, upper surficial-aquifer groundwater samples PA-12, and PA-13, and wells MW-39S, DMW-3S, and DMW-2S (Figure 4-15) have low concentrations of BTEX ranging from 34 to 28 μg/L. As shown in Figures 4-19 and 4-20, BTEX was not detected in other downgradient wells (DMW-3I/D, DMW-18S/I/D, DMW-2A and DMW-2B).

The PHA and Pond 1 BTEX concentrations are shown in cross-section in Figure 4-21. The cross-section shows high concentrations of BTEX in the unsaturated and saturated zones in the PHA and in Pond 1 sediment. As described above, the highest BTEX concentration in

groundwater $(43,520 \,\mu\text{g/L})$ was found at PA-1, southwest of well DMW-9S. High BTEX concentrations were not found in the deeper wells of this well cluster (DMW-9I and DMW-9D), or at any of the surrounding well locations. However, BTEX in groundwater has not been fully characterized southwest and west of DMW-9S and PA-1, and in the area east of Pond 1 between wells DMW-9S/I/D and DMW-3S/I/D.

4.2.2.2 Taxiway Tango Median Anomaly Area

As mentioned previously, the TT Median Area is the open grass area that runs parallel to and between the airport runway on the west and Taxiway Tango to the east. It also includes areas underneath the taxiway and runway, and areas west of the runway. As shown in Figure 4-15, BTEX was not detected or was detected at low concentrations in surface soil at the TT Median Area. Although sampling coverage is sparse, surface soil at the TT Median Area does not appear to represent a BTEX source.

BTEX was detected at elevated concentrations in shallow subsurface soil at the TT Median Area at depths up to 10 feet at TT-EX11 and TT-EX2 (see Figure 4-16). The highest soil BTEX concentration was $2,348,720 \,\mu\text{g/kg}$ in TT sample TT-EX2-T1-5, collected from a depth of five feet. Few deep subsurface soil samples were collected in the TT Median Area (Figure 4-17). However, BTEX was detected at a moderate concentration of $6,997 \,\mu\text{g/kg}$ in a soil sample collected at 18 feet at MIP-58 is between the areas of TT-EX2 and TT-EX3.

As shown in Figures 4-18 to 4-20, BTEX in the TT Median Area has only substantially affected shallow groundwater in the upper surficial aquifer at well DMW-11S (730 μ g/L), MIP-58 (5,224 μ g/L at 9–11 feet), and MIP-61 (317 μ g/L at 13–15 feet). Toluene is the predominant BTEX component in MIP-58 and MIP-61 and is the only BTEX component detected at DMW-11S. Low concentrations of BTEX were detected at DMW-23S and DMW-1S, southeast of DMW-11S and DMW-26S.

Southeast of DMW-11S, soil samples were collected near wells DMW-1A and DMW-1B. Historically, BTEX has been detected in groundwater at wells DMW-1A/B, east of Taxiway Tango; however, the BTEX source was unknown. Samples DR-SB-12-5 and DR-SB-12-9 (near well DMW-1A/B in Figure 4-16) indicate BTEX in shallow subsurface soil at depths of five to nine feet. A sample collected from eight feet deep at test pit A27 (excavated in the DR-SB-12 area) had a BTEX concentration of 506,700 µg/kg, corroborating the results of samples

DR-SB-12-5, and DR-SB-12-9. These results confirm that petroleum hydrocarbons are in the TT Median Area and are likely responsible for BTEX in groundwater in temporary well sampling locations PA-7 and TT-5 (which had a chlorobenzene concentration of 50,000 µg/L), groundwater samples MIP-30 and MIP-26, and wells DMW-1A and DMW-1B (Figures 4-18 through 4-20). Although deep subsurface soil samples have not been collected from the area near well DMW1A/1B area, a soil sample (MIP-30-SS-20) collected at a depth of 20 feet northwest of this area indicates residual levels of BTEX (84.6 µg/kg) in deep subsurface soil.

4.2.2.3 **Drum Area**

BTEX concentrations in surface, shallow subsurface, and deep subsurface soil in the DA (Figures 4-15 through 4-17 and 4-22) do not indicate a significant soil-based BTEX source. BTEX was not detected in most DA soil samples. The maximum BTEX concentration detected in a soil sample is $110 \,\mu\text{g/kg}$ (DR-SB-14-15 at 15 feet), adjacent to wells DMW-7S/I/D (Figure 4-13).

As shown in Figure 4-18, BTEX was detected at moderate to high concentrations in the upper surficial aquifer at DA-6 (26,200 μg/L), MIP-28 (4,632), DA-7 (1,820 μg/L), DA-5 (1,700 μg/L), DA-8 (580 μg/L), and DMW-7S (131 μg/L). Trace concentrations of BTEX were detected in the intermediate and lower surficial-aquifers at wells DMW-7I (0.73 μg/kg) and DMW7D (0.59 μg/kg). BTEX was not detected in the DA trench area at DA-1, DA-2, and DA-3, and south of the DA at MIP-55 and MIP-36. However, the analytical detection limits for DA-1 and DA-3 were elevated; therefore, moderate concentrations of 500–2,500 μg/L (the range of sampling detection limits) for each BTEX component would not have been detected in these two samples.

As shown in Figure 4-22, wells DMW-7S and DMW-5S appear hydraulically connected via a three- to six-feet thick sand layer at the base of both wells. BTEX was detected hydraulically downgradient of the DA in upper surficial aquifer samples DA-9 (590 μg/L), DA-12 (2,200 μg/L), and MIP-41 (10.4 μg/L at 24–26 feet). However, BTEX was not detected downgradient of the DA in the upper surficial aquifer well DMW-5S. The upper surficial aquifer sand layers at wells DMW-7S and DMW-5S are underlain by 2.5–9 feet of clay, which would be expected to attenuate the downward movement of BTEX to the intermediate and lower surficial-aquifer zones. This is confirmed by the absence of BTEX detections at DMW-5I/D and the substantially lower BTEX

concentrations (less than 1 μ g/L) at DMW-7I/D and MIP-41 (39 to 41 feet deep) (see Figures 4-19 4-20, and 4-22).

TRICHLOROETHENE EQUIVALENT AND CHLORINATED VOC CONCENTRATIONS IN GROUNDWATER FOR THE UPPER SURFICIAL AQUIFER, DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIPORT, MIDDLE RIVER, MARYLAND PAGE 1 OF 3

TABLE 4-1

Well or Boring ID	TCE Equivalent [TCE _(EQ)] Concentration μg/L	TCE Concentration μg/L	cis-1,2-Dichlroethene Concentration μg/L	Vinyl Chloride Concentration µg/L
MW-3	18	0.83 J	10	1.7
MW-4		0.17 U	0.17 U	0.22 U
MW-5	5560	51 J	2900	750
MW-6		0.17 U	0.17 U	0.22 U
DMW-1S	160	15	65	27
DMW-2S	5421	2700	1200	520
DMW-3S	7457	17 U	1000	2900
DMW-4S	1430	1200	120	32 J
DMW-5S	11334	9300	1500	55 U
DMW-6S	2.7	0.53 J	1.6	0.22 U
DMW-7S	43352	8050	24100	1250
DMW-8S	0.53	0.17 U	0.39 J	0.22 U
DMW-9S	54930	790 J	12000	18000
DMW-10S	800	3.4 U	3.4 U	380
DMW-11S	52648	12000	23000	4500
MW-15S	91	63	20	0.74 J
MW-16S	358	0.17 U	62 L	130 L
MW-17S	16	0.17 U	1.2	6.9
MW-18S	3111	2500	280	110
MW-20S	3850	320	1300	840
MW-23S	29	0.17 U	3	12
MW-24S		0.17 U	0.17 U	0.22 U
MW-25S	348	56	200	10
MW-26S	90	0.28 U	12	35
MW-32S		0.17 U	0.17 U	0.22 U
MW-33S	9.9	5.3	3.4	0.22 U
MW-34S	5.5	0.17 U	2.2	1.2
MW-35S	17	3.4	7.7	1.5
MW-36S		0.17 U	0.17 U	0.22 U
MW-37S		0.17 U	0.17 U	0.22 U
MW-38S		0.17 U	0.17 U	0.22 U
MW-39S	58	12	15	12
DA-1	17558	12000	4100	2500 U
DA-2		10 U	ND	10 U

TRICHLOROETHENE EQUIVALENT AND CHLORINATED VOC CONCENTRATIONS IN GROUNDWATER FOR THE UPPER SURFICIAL AQUIFER, DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIPORT, MIDDLE RIVER, MARYLAND PAGE 2 OF 3

TABLE 4-1

Well or Boring ID	TCE Equivalent [TCE _(EQ)] Concentration µg/L	TCE Concentration µg/L	cis-1,2-Dichlroethene Concentration μg/L	Vinyl Chloride Concentration µg/L
DA-3	57102	48000	6000	460
DA-4	70283	64000	4200	280
DA-5	92314	53000	29000	5000 U
DA-6	67586	33000	25000	330
DA-7	191384	130000	45000	180
DA-8	72846	70000	2100	500 U
DA-9	30926	7300	16000	920
DA-10	4112	550	2500	82
DA-11	1217	1000	160	500 U
DA-12	219207	2300	160000	2500 U
DA-13	174259	1900	120000	4600
DA-14	8.80	2.0	5	10 U
MIP-25	4386	416	1910	656
MIP-26	70	19.8	14.5	14.5
MIP-30	16939	2020	2950	5190
MIP-35	1513	826	475	20.6
MIP-39	207	3.4	6.8	92.2
MIP-41	13744	8780	3460	130
MIP-51	305	7.6	13.3	133
MIP-58	98798	3610	66800	2200
MIP-61	26717	3630	13600	2210
PA-1	62113	310	31000	9400
PA-2	5049	10 U	ND	2400
PA-3	6305	ND	150	2900
PA-4	860	36	220	250
PA-5	122	16	7	46
PA-6	ND	ND	ND	ND
PA-7	266468	220000	29000	3400
PA-8	19	16	2	ND
PA-9	287	3	160	32
PA-10	22	6	12	10 U
PA-11	695	490	100	33
PA-12	28	7	6	6
PA-13	8406	500 U	1700	2900
PA-14	69	3	16	21

TABLE 4-1

TRICHLOROETHENE EQUIVALENT AND CHLORINATED VOC CONCENTRATIONS IN GROUNDWATER FOR THE UPPER SURFICIAL AQUIFER, DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIPORT, MIDDLE RIVER, MARYLAND PAGE 3 OF 3

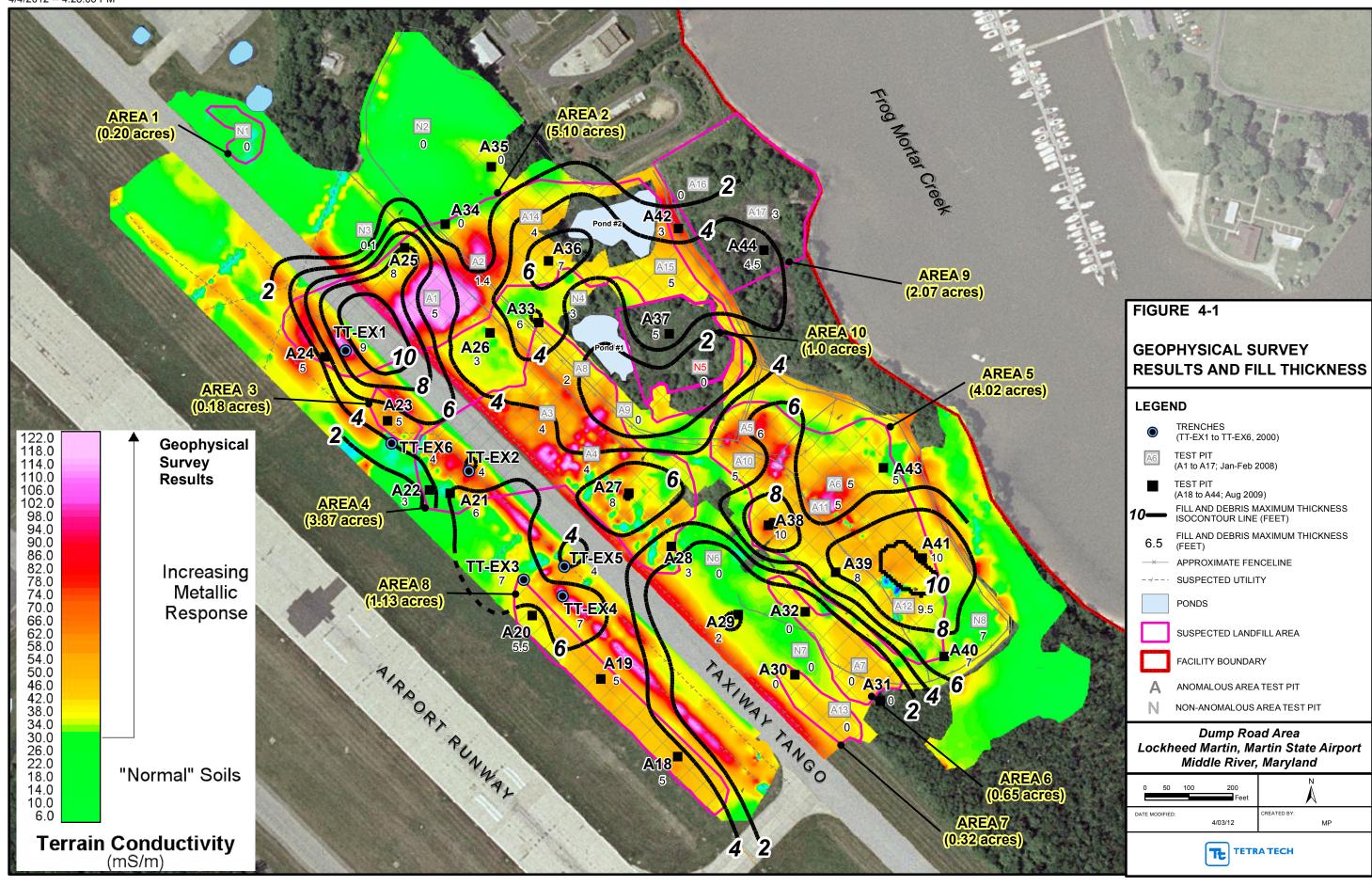
Well or Boring ID	TCE Equivalent [TCE _(EQ)] Concentration μg/L	TCE Concentration µg/L	cis-1,2-Dichlroethene Concentration μg/L	Vinyl Chloride Concentration µg/L
PA-15	59570	1000	1300	27000
PA-16	1091	83	92	420
SB-13	4.7	2	2	5 U
TT-1	2	2	5 U	10 U
TT-2	1	1	5 U	ND
TT-3	15349	500 U	1700	6200
TT-4	17259	500 U	470 J	7900
TT-5		5000 U	5000 U	5000 U
TT-6	4091	500 U	1000	1300
TT-7	456	10 U	150	120
TT-8	30	10 U	11	7
TT-9	21	10 U	10 UJ	10
TT-10	520	12	49	210
TT-11	1	1 U	1 U	1 U
TT-12		1 U	1 U	1 U
TT-13		1 U	1 U	1 U
TT-14	215	23	100	27

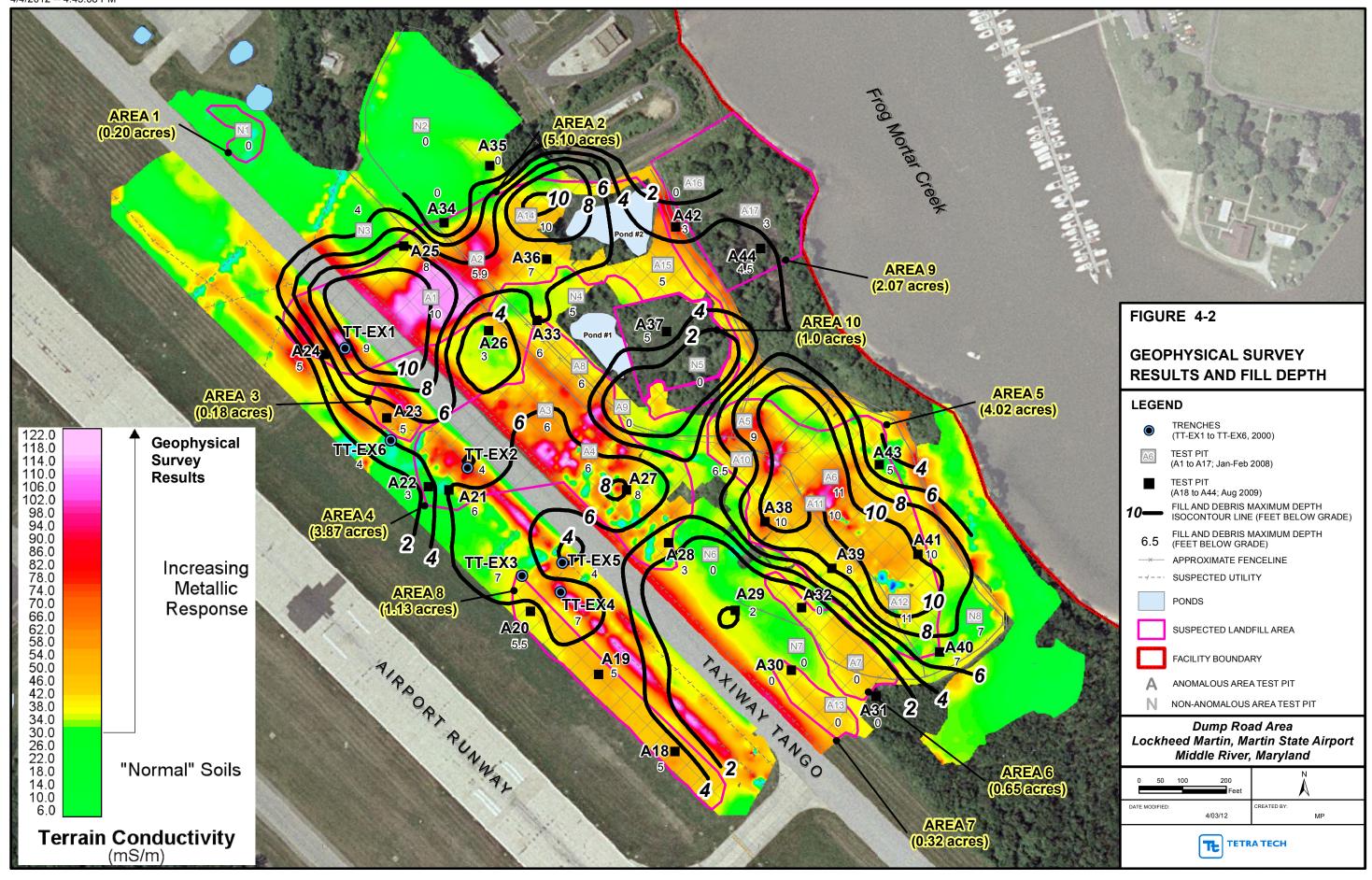
 $\mu g/L = micrograms per liter$

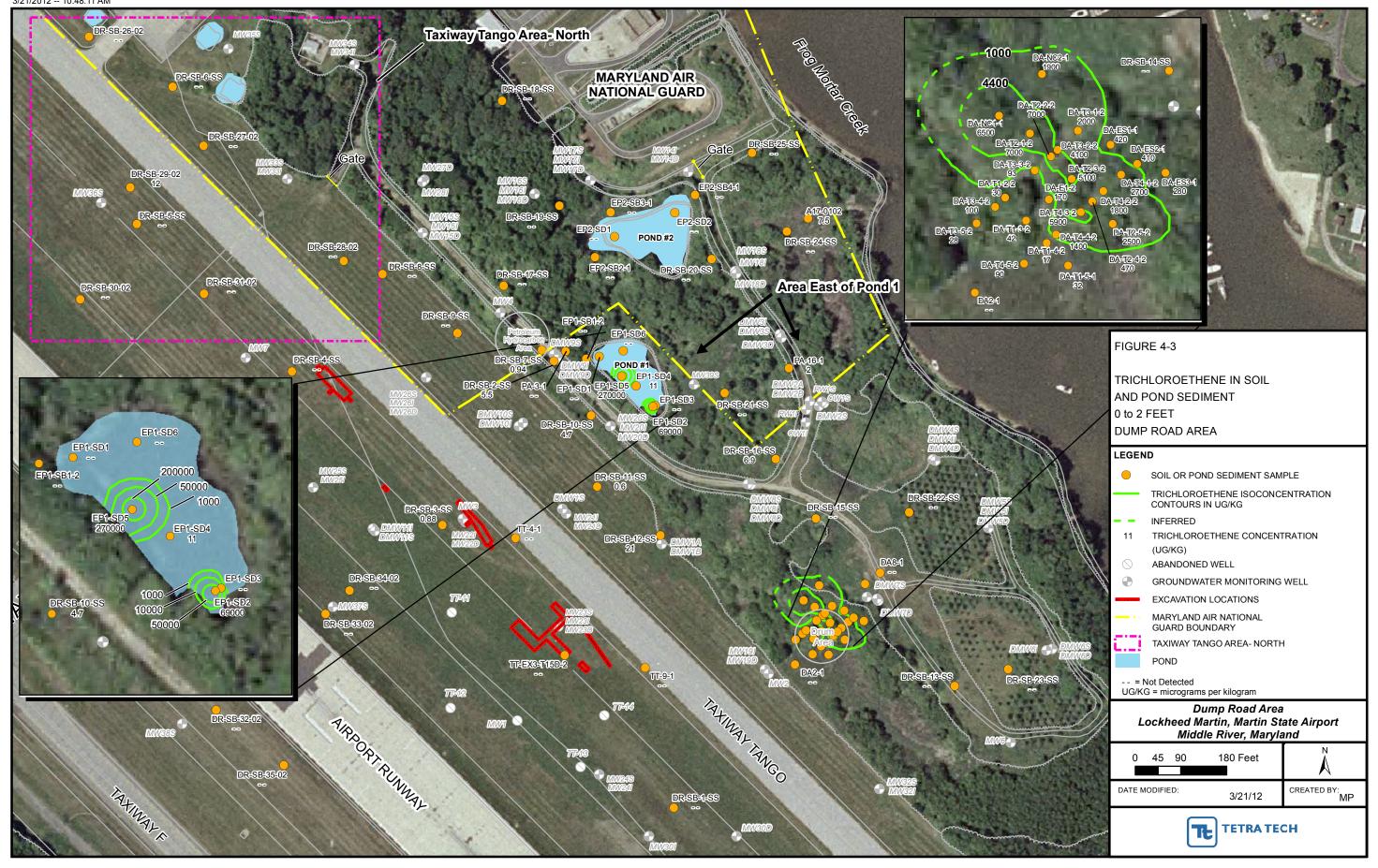
ND = Indicated as not detected. Detection limit not listed.

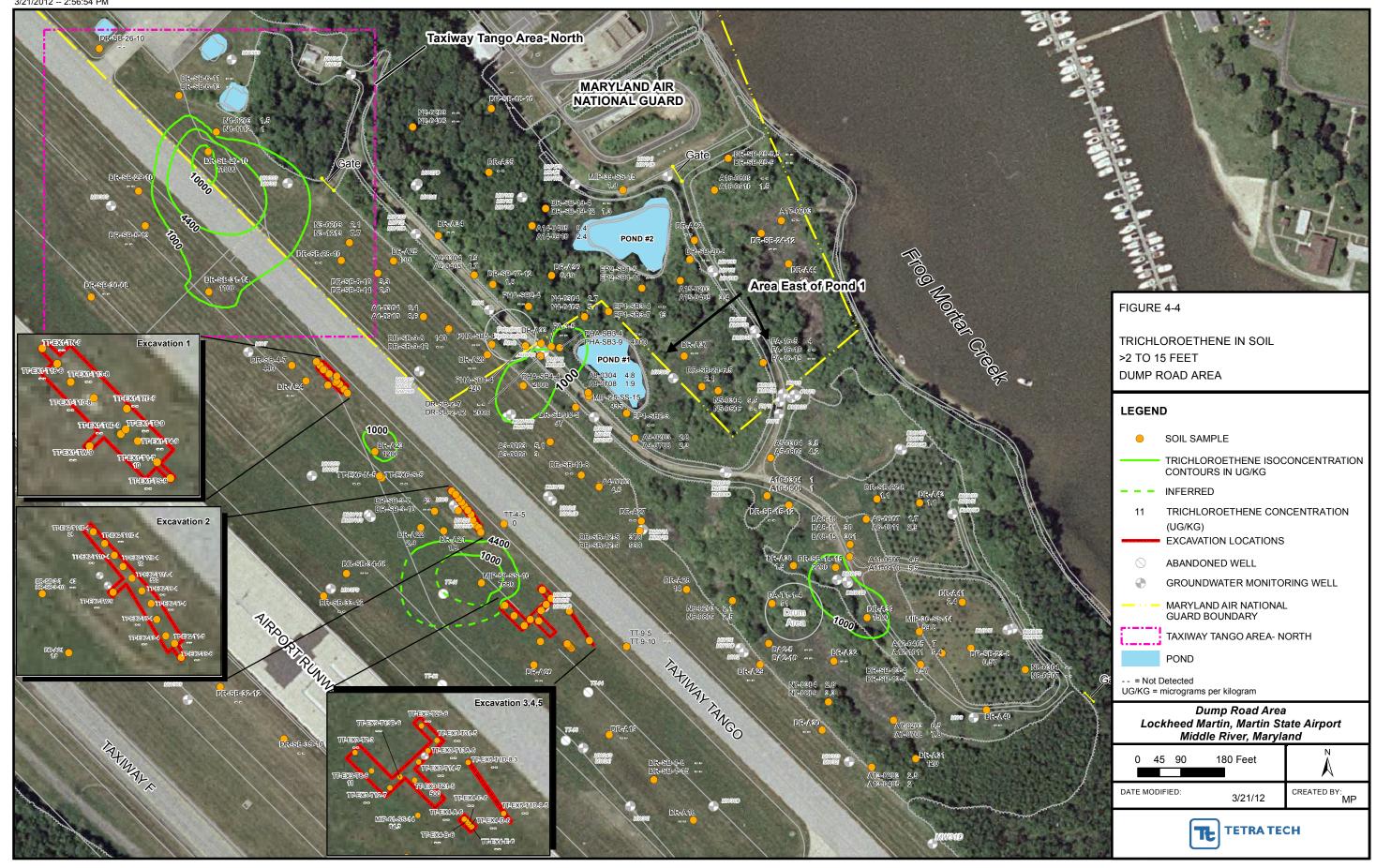
- B Not detected. Result is considered to be from laboratory blank contamination based on USEPA 5 times or 10 times rule.
- J Positive result is considered estimated as a result of technical noncompliance.
- L Positive result is considered to be biased low as a result of technical noncompliance.
- U Not detected at the detection limit shown left of the letter.

⁻⁻ = Trichloroethene equivalent [TCE_(EQ)] not computed because VOCs were not detected.

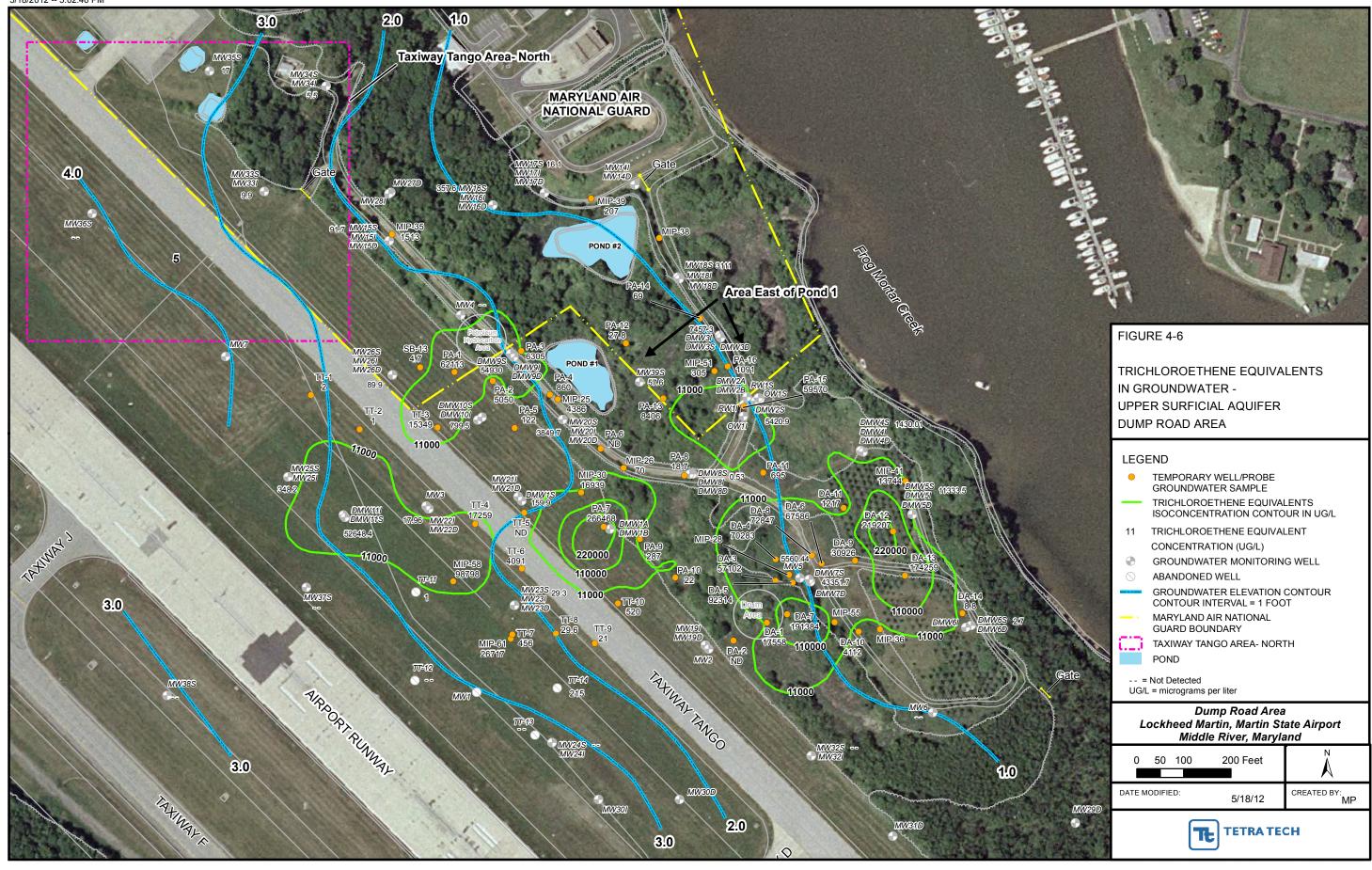


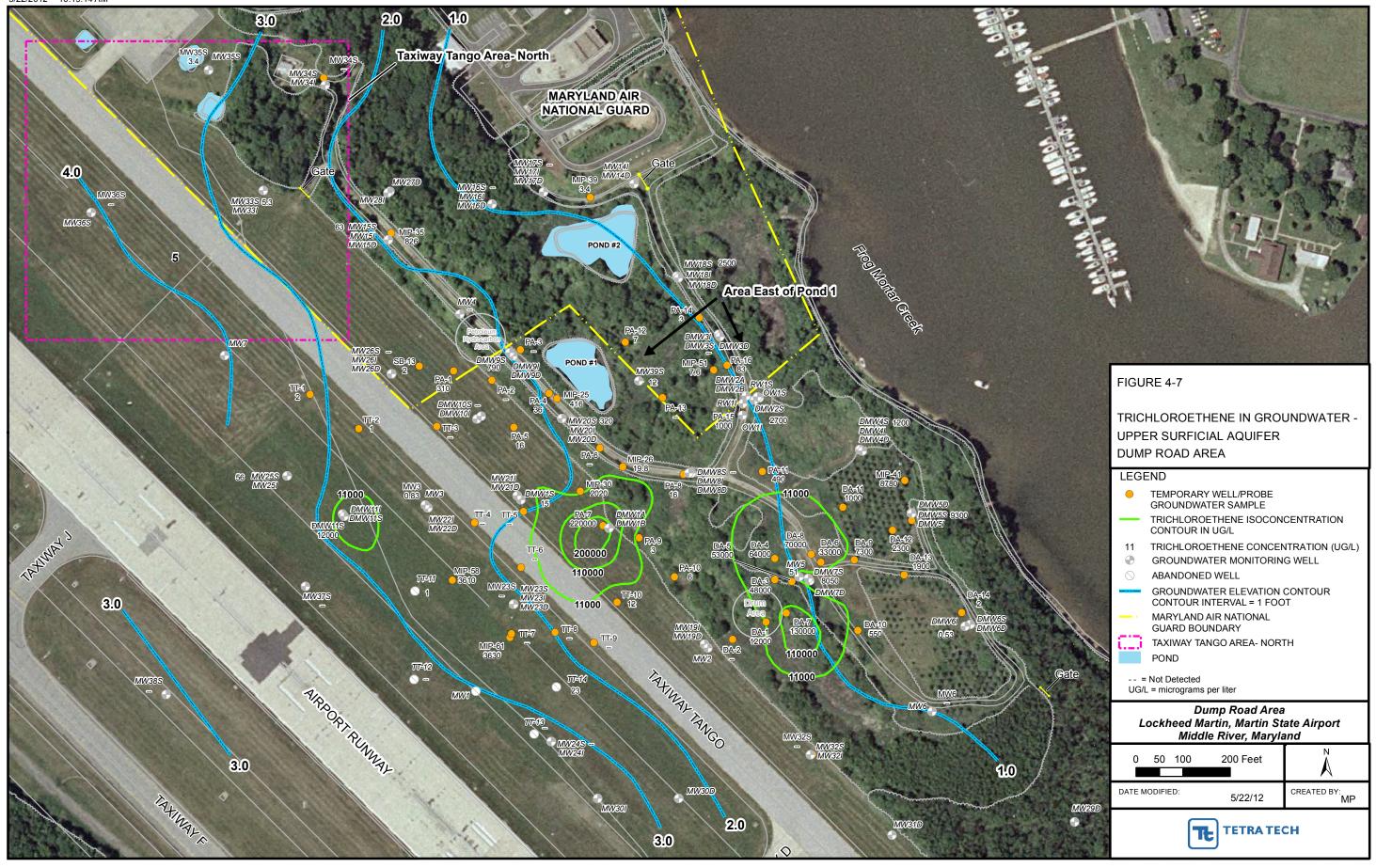


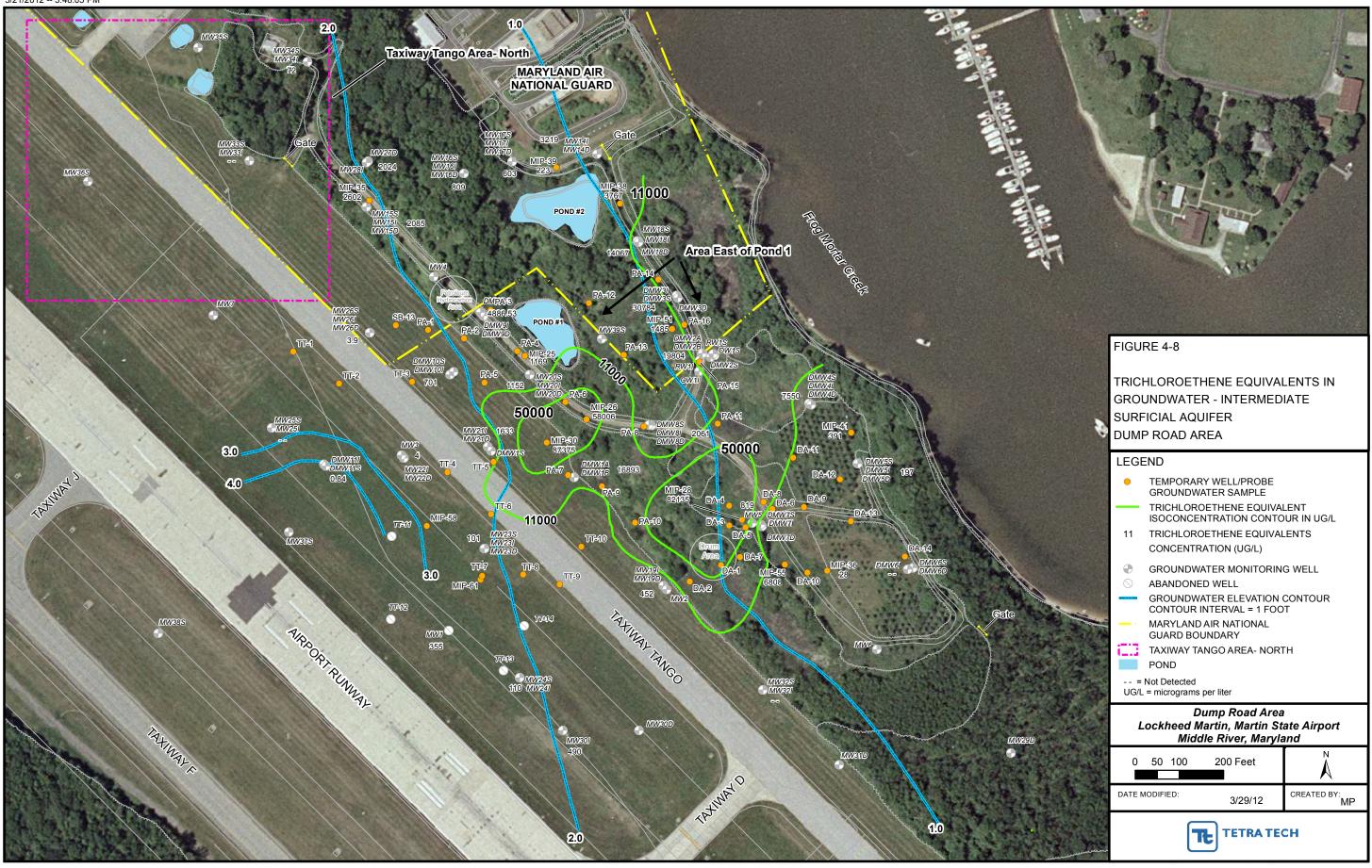




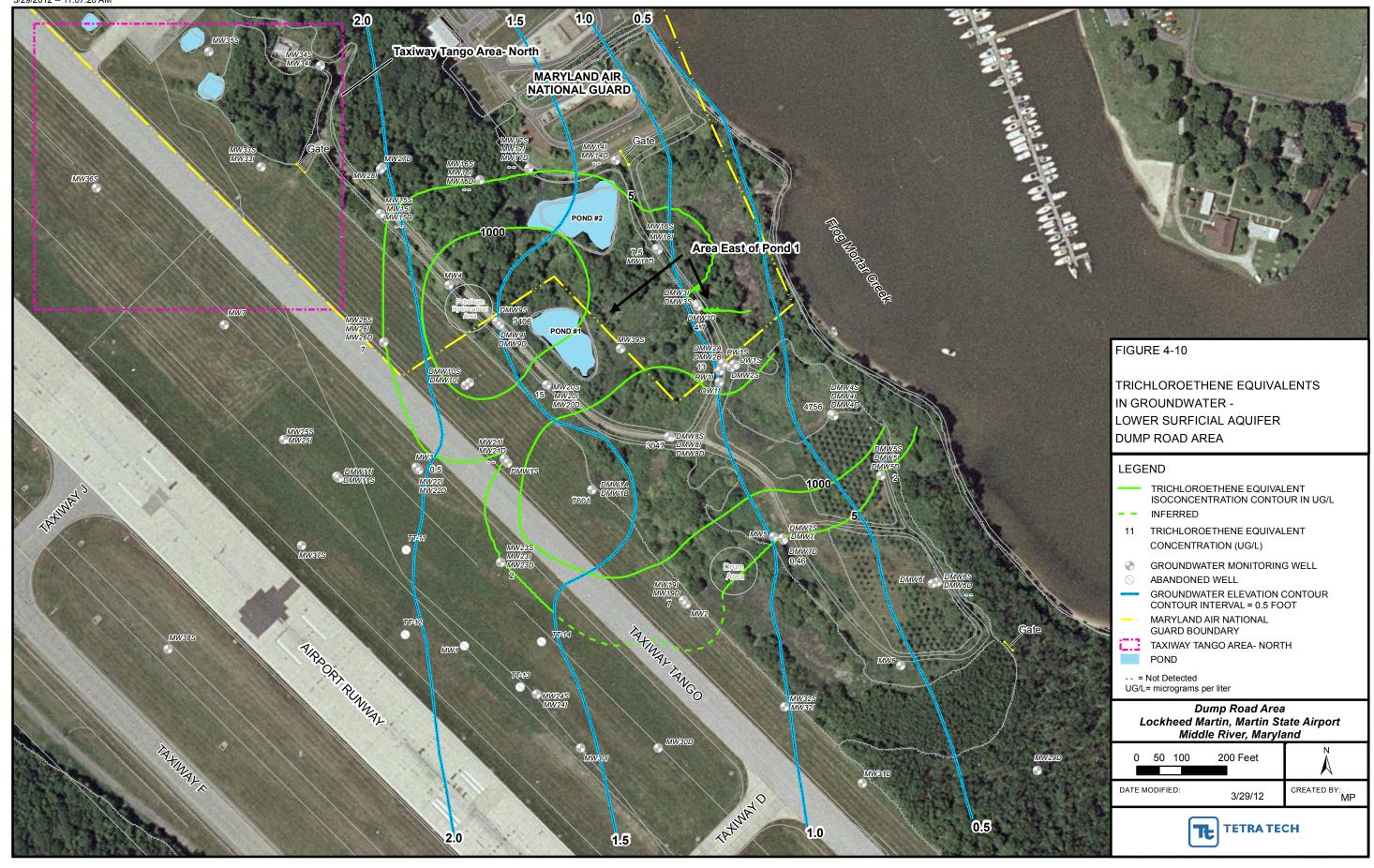


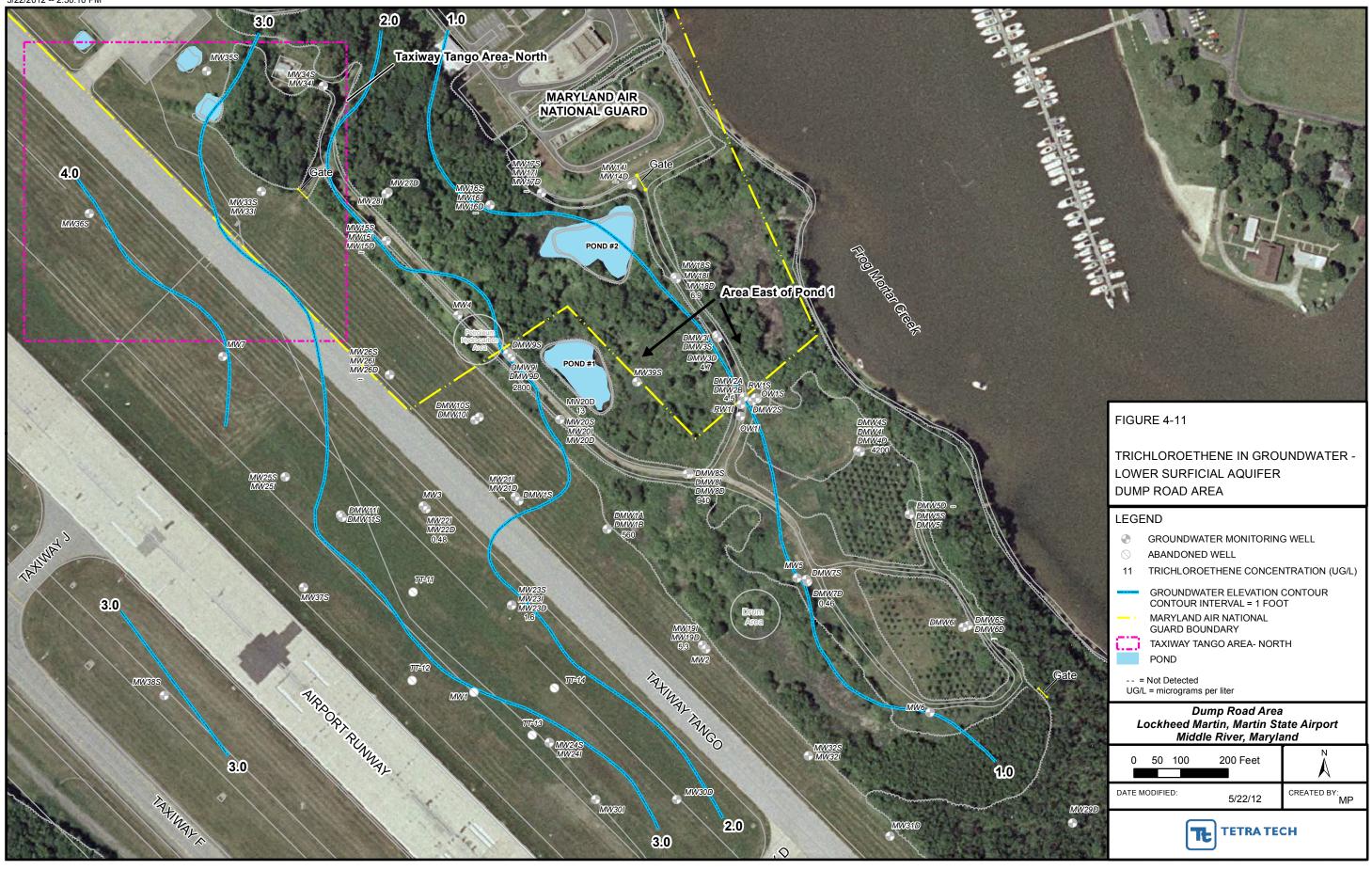


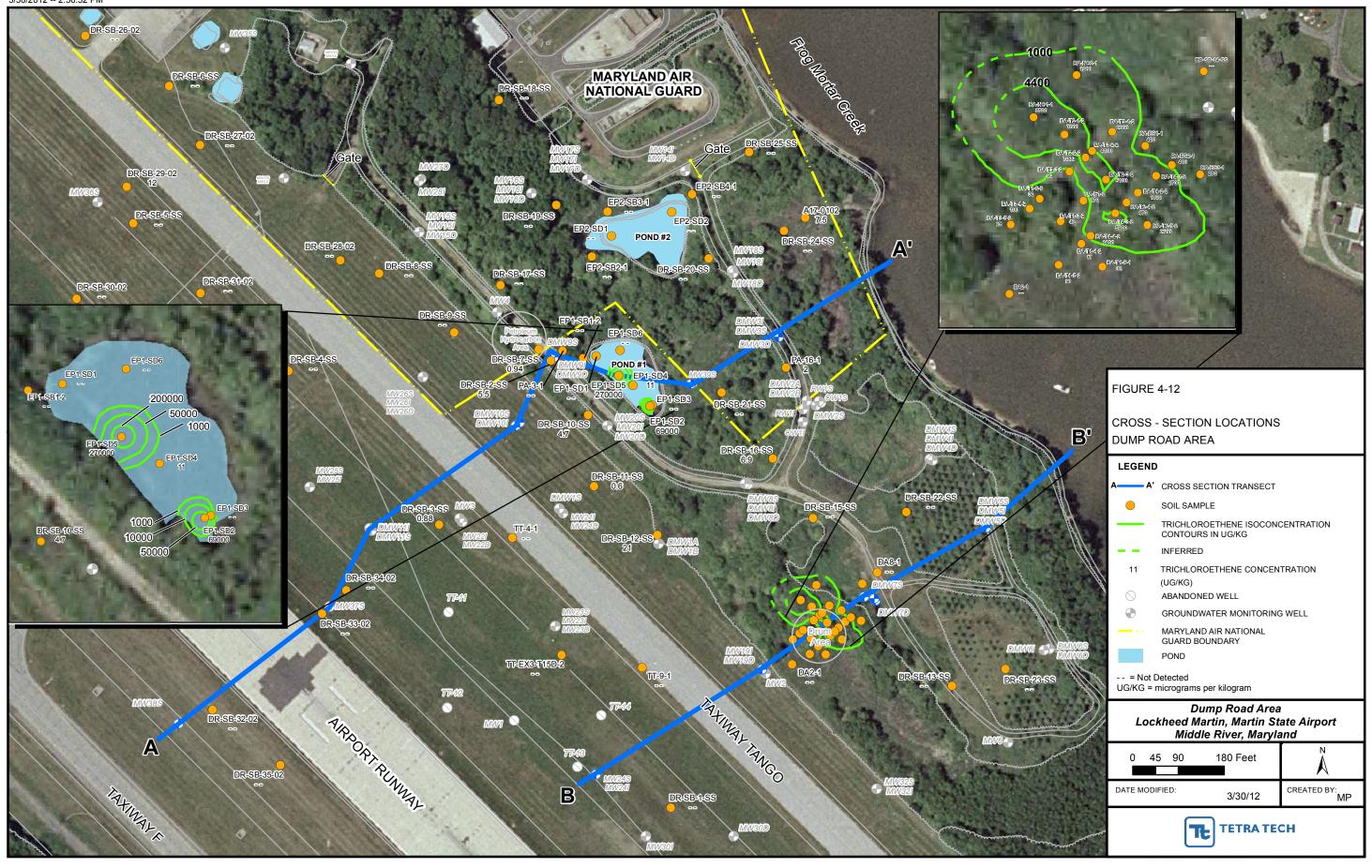


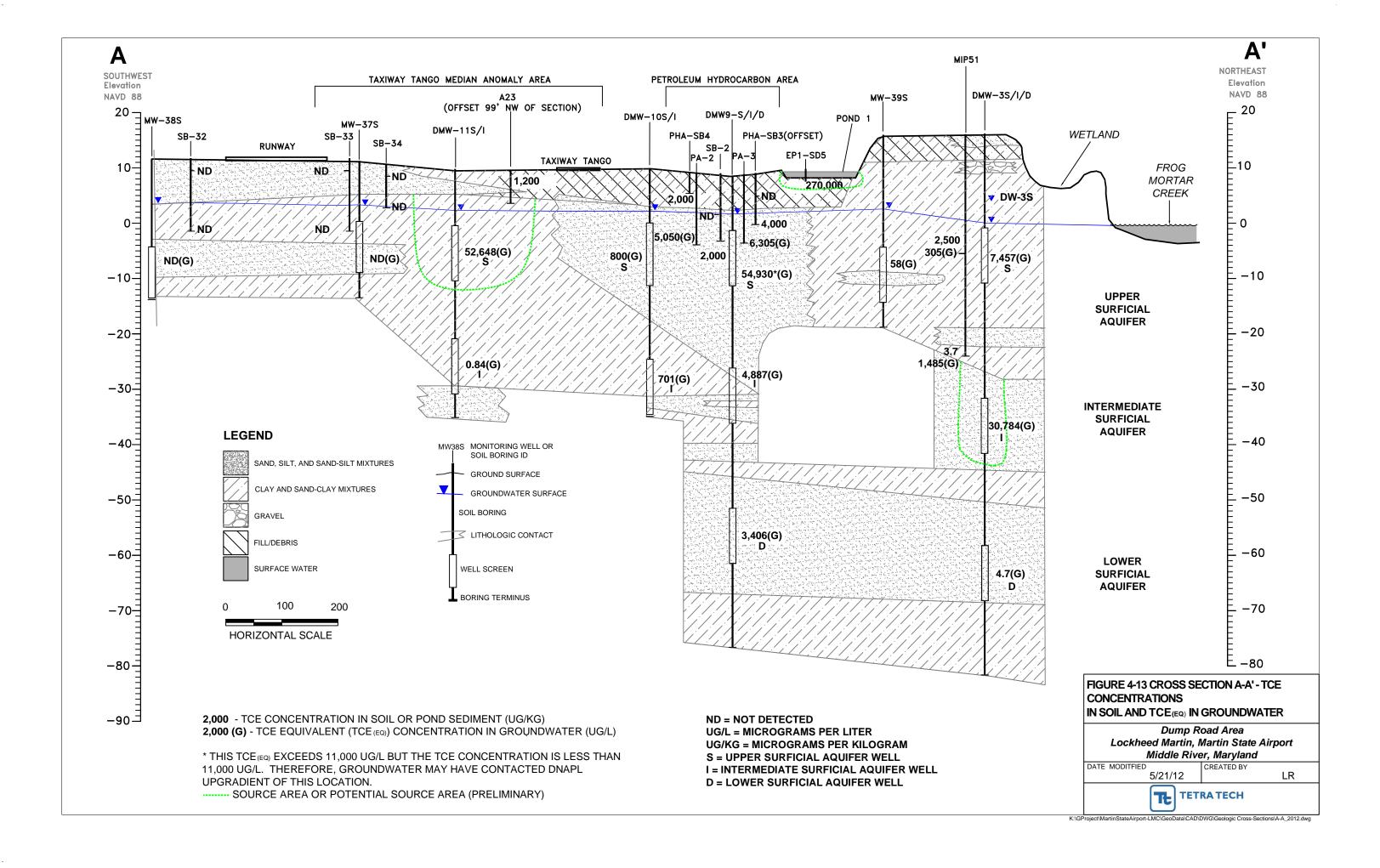


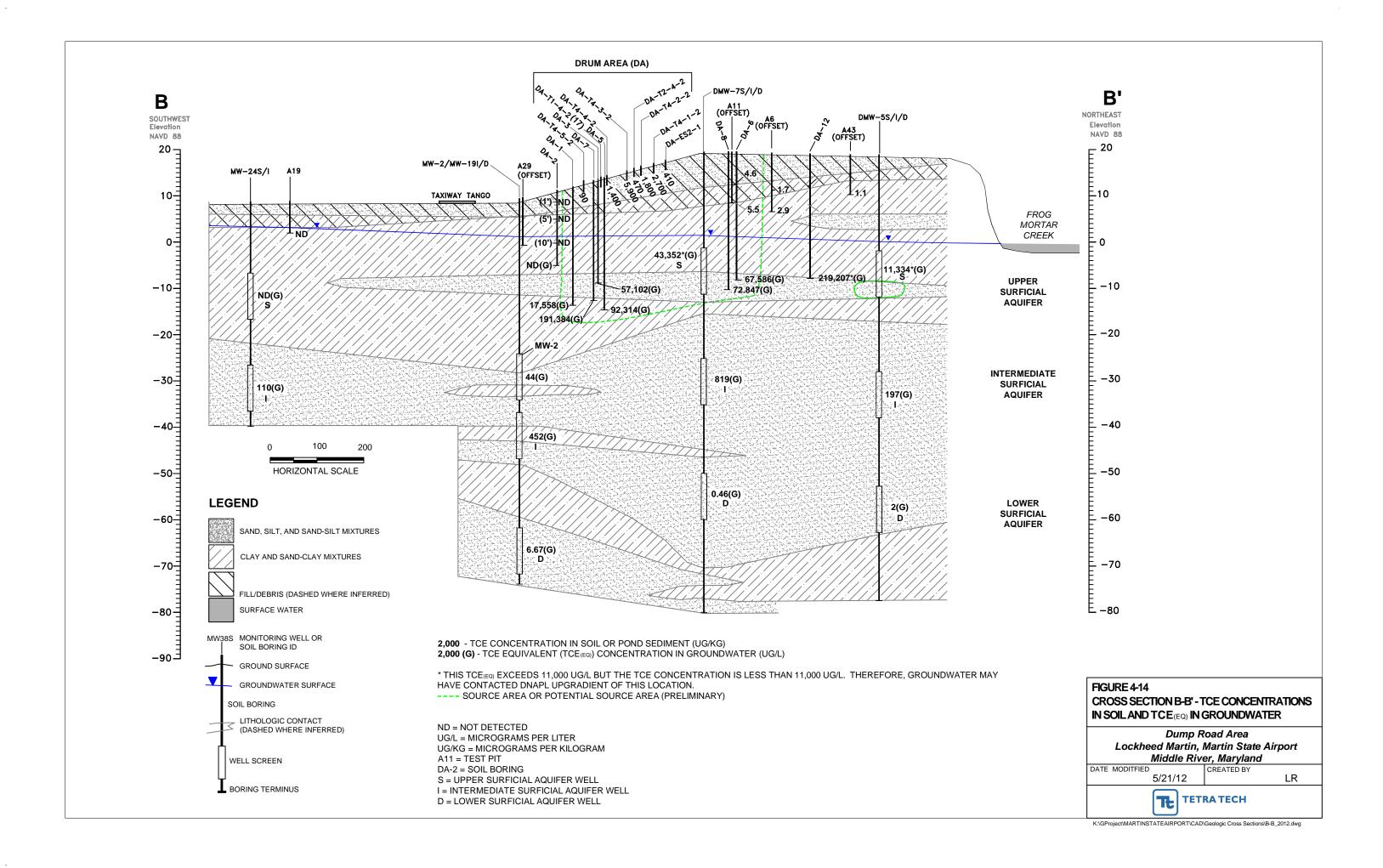


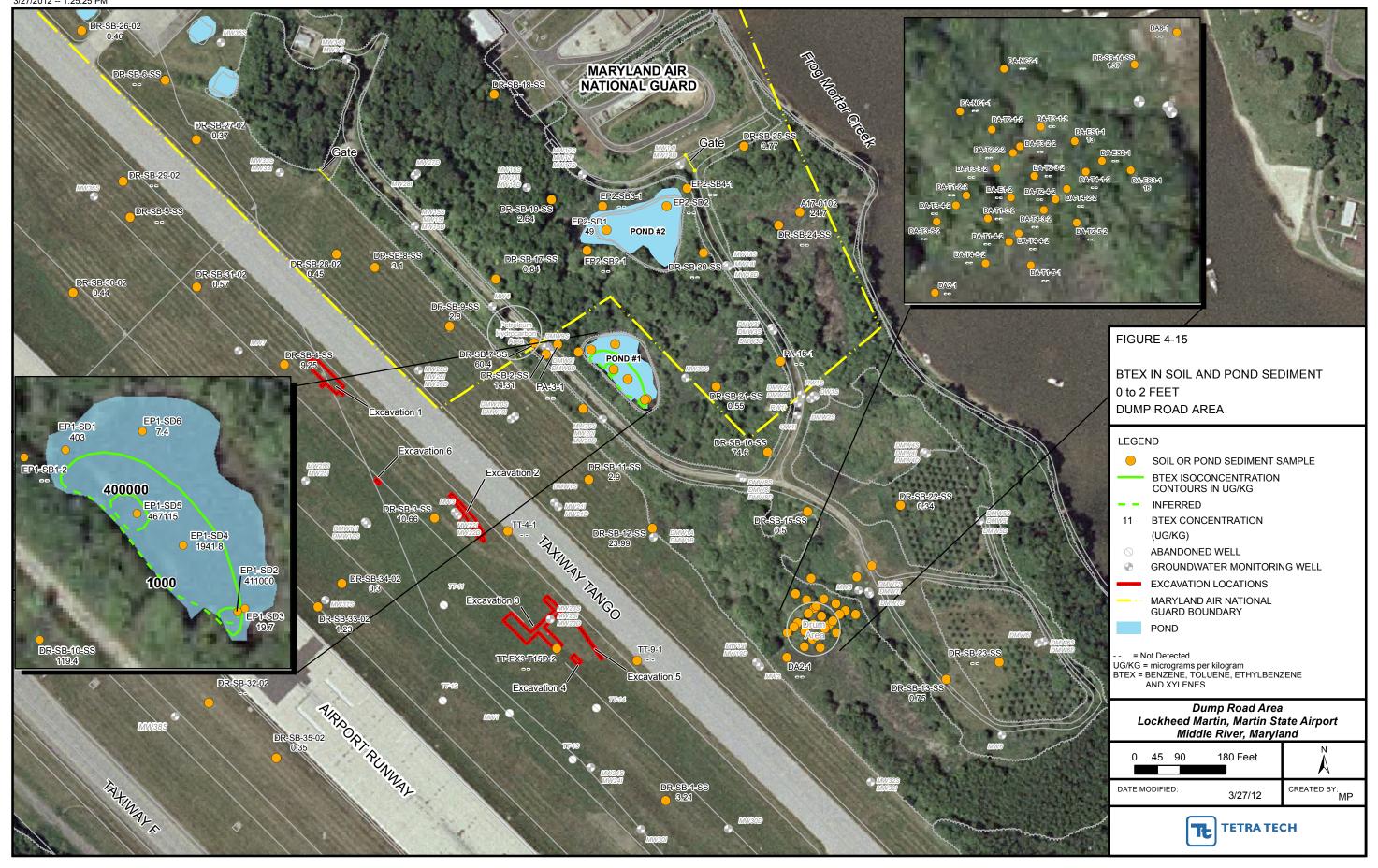


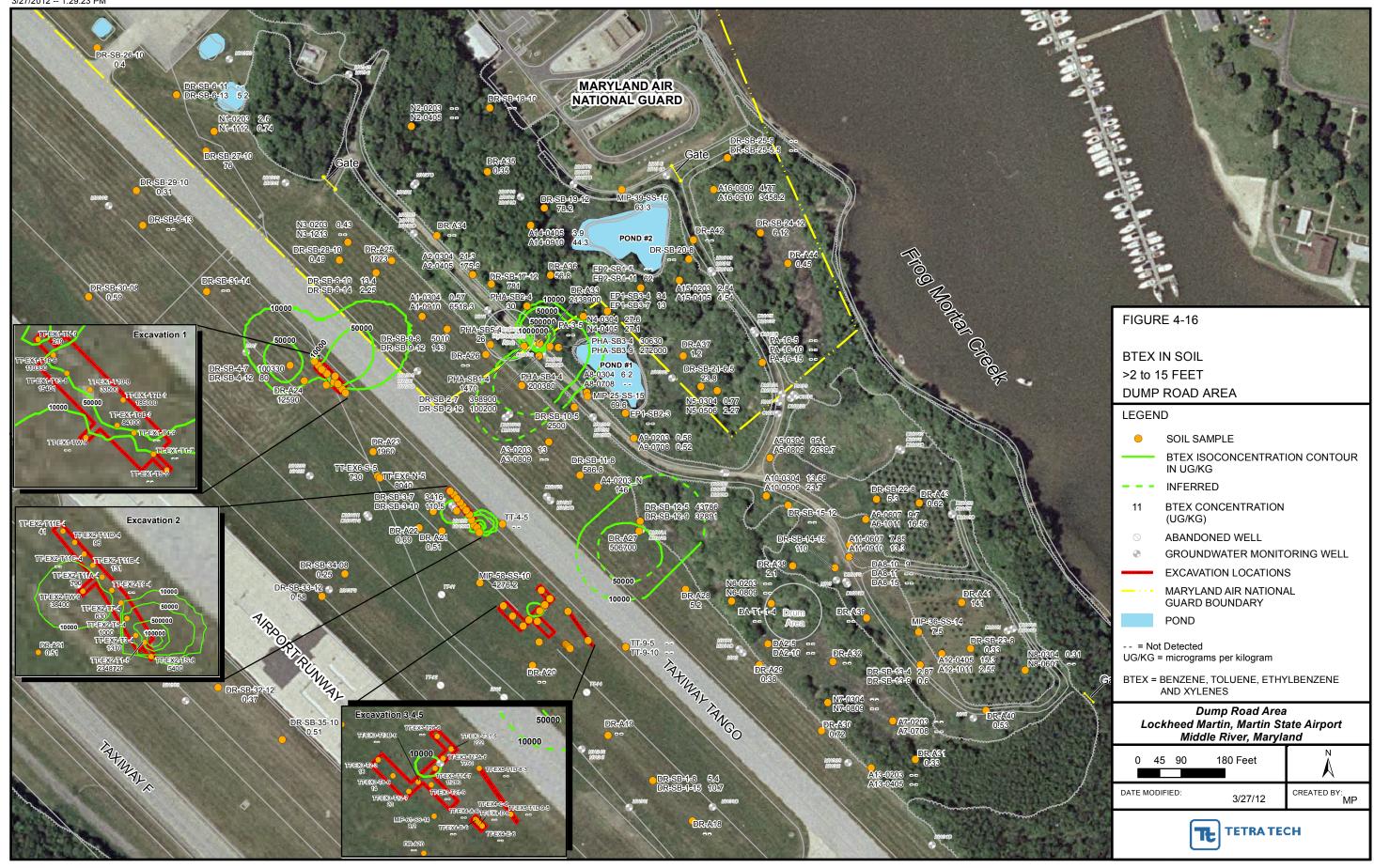




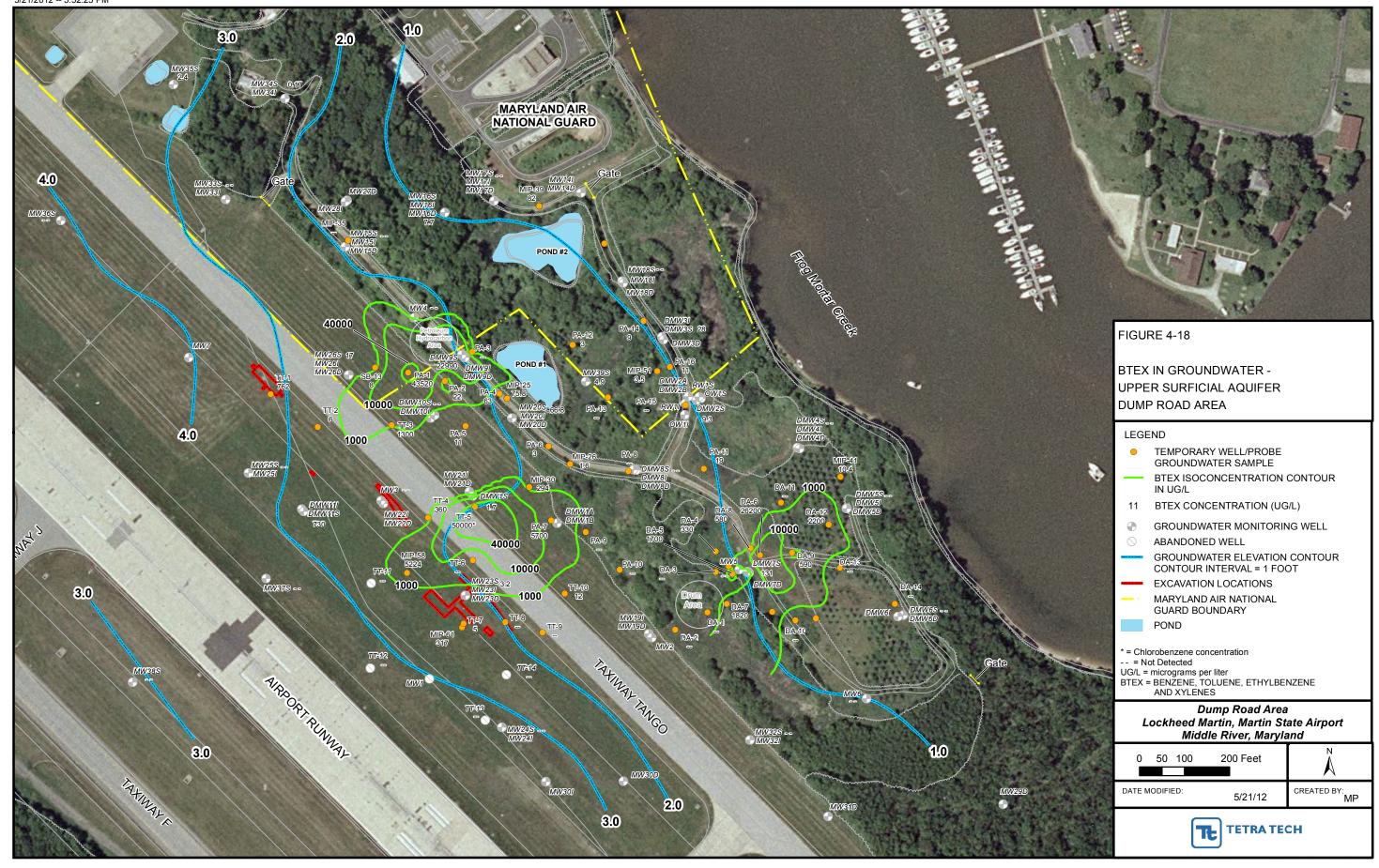




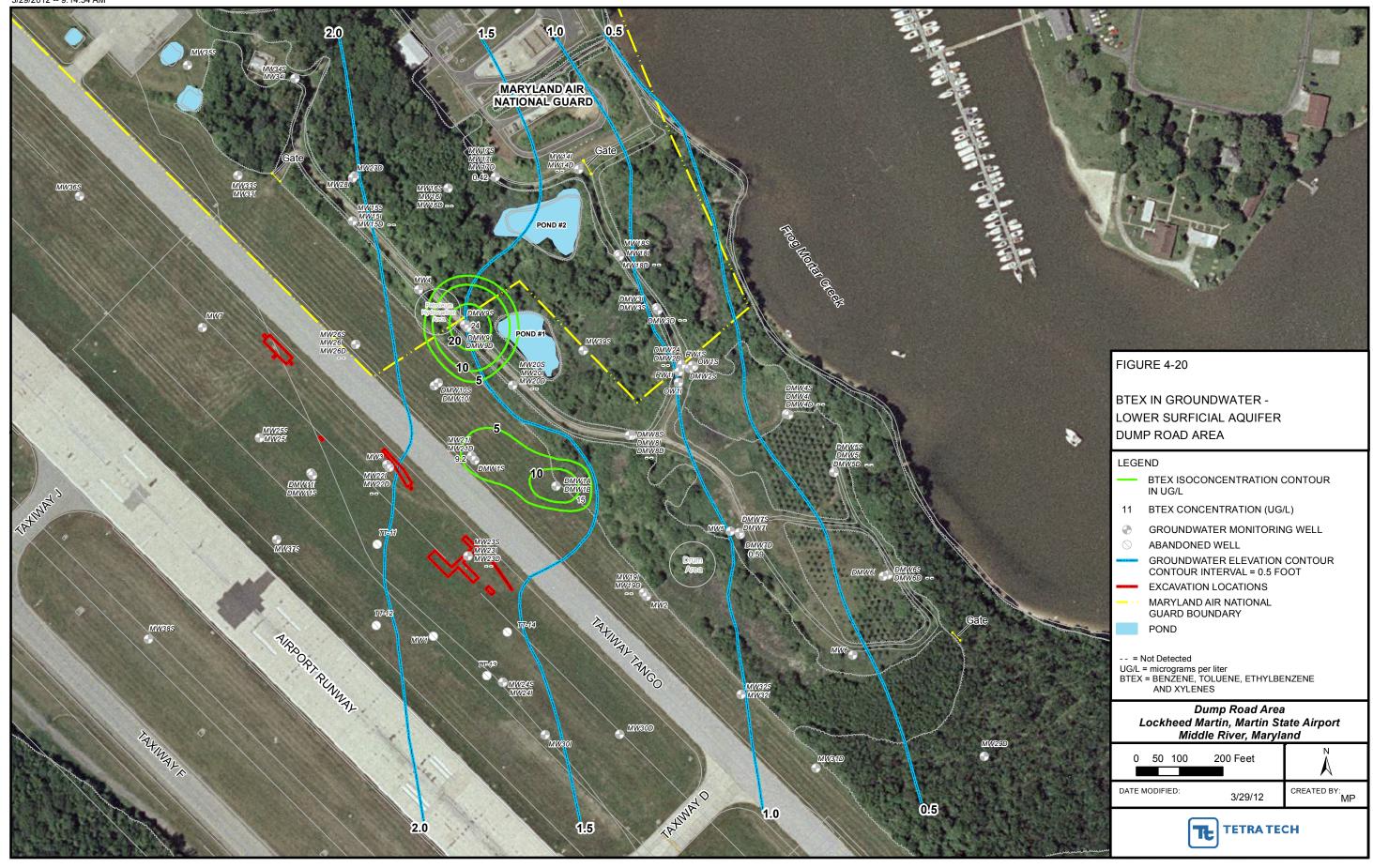


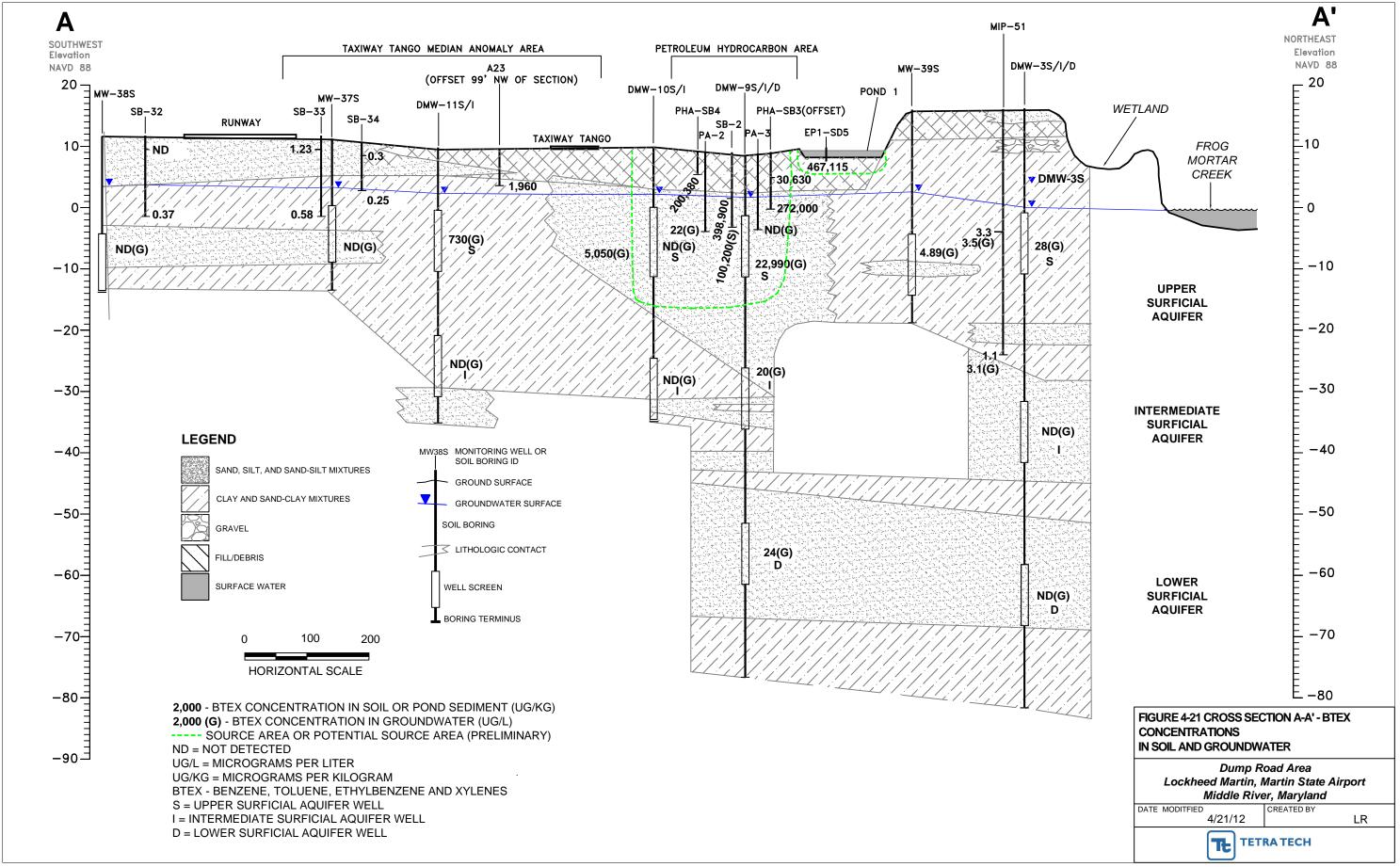


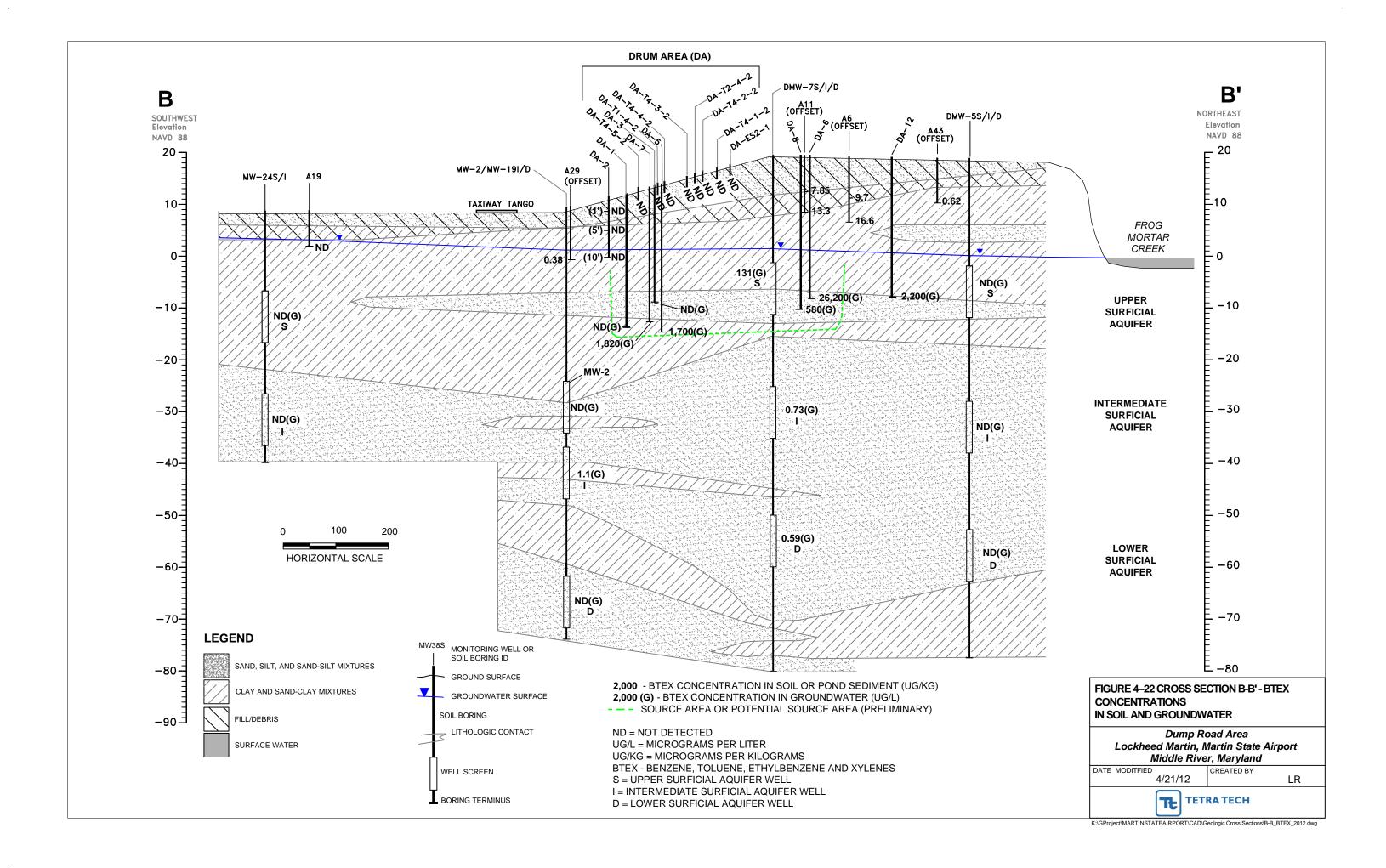












Section 5 Summary and Recommendations

5.1 SUMMARY

This technical memorandum documents the results of a study to describe and evaluate possible source areas of volatile organic compounds (VOCs) in soil and groundwater at the Dump Road Area (DRA) site at Martin State Airport (MSA) in Middle River, Maryland. The Dump Road Area is an unlined dump; therefore, large areas or areas of thick fill and/or buried debris were expected of being possible soil and groundwater contaminant sources. During the 1930s through 1960s, three pits are reported to have been used to dump spent battery acid, acid-type strippers, and other acidic solutions. Dredge spoils and construction debris associated with industrial operations also were reportedly placed in these pits.

The Maryland Department of the Environment (MDE) found only two pits during site visits conducted as part of the 1989 preliminary assessment (PA). MDE referred to these two pits as ponds, which were then named Pond 1 and Pond 2 in subsequent studies. Early environmental investigations from 1991–1996 identified four areas of concern:

- Taxiway Tango Median Anomaly Area (TT Median Area)
- Drum Area (DA)

• Pond 1 and Pond 2

• Petroleum Hydrocarbon Area (PHA)

Numerous studies, including a remedial investigation (RI) and human health and ecological risk assessments, have been conducted to date to provide environmental and engineering data to characterize site contaminants, evaluate risk to potential receptors, and select and design remedial actions.

A geophysical-survey of accessible portions the Dump Road Area was conducted in 2007 and numerous test pits were excavated to delineate the extent of fill and debris and identify the types of waste buried there. Geophysical survey results indicate contiguous areas of fill and buried

debris. These geophysical anomaly areas are designated Areas 1–10 for investigation purposes, and range in size from 0.18 acres at Area 3 to 5.10 acres at Area 2.

The maximum fill and debris thickness/depth (11 feet) is at Area 5. Area 5 is a large fill and debris area northeast of the Drum Area between wells DMW-7S/I/D and DMW-5S/I/D. Some of the highest concentrations of chlorinated volatile organic compounds in groundwater at the site were detected in several Drum Area temporary-well samples, in direct push technology (DPT) probe samples, and at wells DMW-7S and DMW-5S. These samples also contain trichloroethene (TCE) concentrations indicative of possible dense non-aqueous phase liquids (DNAPLs). Debris encountered in Area 5 test pits includes 55-gallon drums, metal scraps, glass, burned materials, plastic, wood, and vehicle parts. The estimated area of debris across the Dump Road Area is approximately 25 acres.

Soils in test pits in several of the other areas contained fill and debris, as follows:

- Area 3—petroleum staining, odors, rebar, transformer fuses, electronic tubes, scrap metal, and a drum
- Area 4—drums, creosote stains, scrap metal, wood, an unidentified white crystalline material, black-stained soil, and odors
- *Area 8*—black discolored soils, acute odors, a 30-gallon drum, rebar, glass, concrete, scrap metal, wood, and brick (Area 8)

In addition, the fill material at non-anomalous test-pit N4, north of Pond 1, contained a greenish-black liquid and an odor that provided a field-instrument reading of 700 parts per million-volume (ppmv) for volatile organic compounds in air. At test pit A16, east of Pond 2, a strong odor similar to paint thinner was encountered. Groundwater with a sheen and black sludge-like soil with a noticeable odor were also observed in the test pit. Free product was observed at depths of four to seven feet in a 1996 soil boring (boring B-15) northwest of Pond 1, in an access road near the Petroleum Hydrocarbon Area. A volatile organic compound reading of 9,300 parts per million was recorded for soil at six feet below grade, which is the depth to the groundwater table.

Chemical analytical results of soil and groundwater samples collected from soil borings, test pits, and monitoring wells during previous investigations at the Dump Road Area were used in this study to describe and assess the source areas for the industrial solvent trichloroethene and the

petroleum hydrocarbons benzene, toluene, ethylbenzene, and xylenes (BTEX), which are in groundwater at the Dump Road Area in excess of Maryland groundwater standards. The study identified possible source-area data gaps and describes additional actions required to further characterize source areas. Soil and groundwater chemical results were also evaluated to identify possible areas of trichloroethene dense non-aqueous-phase liquids; these free-product sources can remain in the subsurface for long periods and provide continuous sources for dissolved-phase groundwater plumes.

A saturation threshold concentration (C_D) and partitioning-threshold concentration (C^T) was calculated to evaluate soil and sediment sampling results for dense non-aqueous phase liquids. A saturation threshold concentration of 9,188,000 micrograms per kilogram (μ g/kg), and partitioning threshold concentrations of 515,000 micrograms per kilogram for vadose-zone soil samples and a 535,000 micrograms per kilogram threshold concentration for soil in groundwater or saturated pond sediment, were computed for this study using typical soil and chemical characteristics available in the scientific literature. A soil trichloroethene concentration greater than 9,188,000 micrograms per kilogram was considered conclusive evidence of a dense non-aqueous phase liquid in soil. A trichloroethene concentration above 515,000 micrograms per kilogram in unsaturated soil, or above 535,000 micrograms per kilogram for saturated soil, would only indicate the possible presence of dense non-aqueous phase liquid in the unsaturated or saturated zones.

For groundwater, a threshold screening concentration of 11,000 micrograms per liter (μ g/L) was used to screen groundwater sampling results for trichloroethene dense non-aqueous-phase liquids, which can act as continuing sources of highly mobile, dissolved-phase volatile organic compounds in groundwater. The screening concentration is equivalent to 1% of the effective solubility ($C_{i(1\%)}$) for trichloroethene in water. In groundwater, a sample concentration exceeding 1% trichloroethene solubility in water indicates that the groundwater may have come in contact with dense non-aqueous phase liquids. Trichloroethene equivalent (TCE_{EQ}) concentrations were computed for the groundwater samples collected in 2011; these concentrations were compared against the trichloroethene dense non-aqueous-phase-liquid screening concentration of 11,000 micrograms per liter.

As shown in Figure 5-1, five areas exhibiting elevated concentrations of trichloroethene in sediment, soil, and/or groundwater were identified in this study:

- Petroleum Hydrocarbon Area and Pond 1 (surface sediment/subsurface soil, groundwater)
- Taxiway Tango Anomaly Median Area (subsurface soil, groundwater)
- Drum Area (surface and subsurface soil, groundwater)
- Taxiway Tango Area—North (subsurface soil)
- Area east of Pond 1(subsurface soil, groundwater)

Figure 5-2 shows the four areas with elevated concentrations of benzene, toluene, ethylbenzene, and xylenes in surface soil/sediment, subsurface soil, and groundwater identified in this study:

- Petroleum Hydrocarbon Area and Pond 1 (surface sediment/subsurface soil, groundwater)
- Taxiway Tango Anomaly Median Area (subsurface soil, groundwater)
- Taxiway Tango Area—South (subsurface soil; groundwater)
- Drum Area (groundwater)

Although light non-aqueous-phase liquids (LNAPL) have been observed at soil borings and test pits (e.g., floating oil sheens, apparent product at or above the water table, etc.), dense non-aqueous-phase liquids have not been directly observed in soil or groundwater samples collected during drilling and sampling at the Dump Road Area. photoionization-detector (PID) readings for subsurface soil samples or odors may be from high concentrations of volatile organic compounds or possibly dense non-aqueous phase liquids, but field screening results or odors alone do not indicate dense non-aqueous phase liquids. Concentrations of trichloroethene in soil samples are less than the threshold chemical concentrations used to evaluate whether trichloroethene dense non-aqueous phase liquids are present (553,000 micrograms per kilogram for samples in groundwater or saturated pond sediment, and 515,000 micrograms per kilogram for vadose zone samples). However, the two highest concentrations of trichloroethene detected in Pond 1 sediment samples (270,000 and 69,000 micrograms per kilogram) indicate that trichloroethene dense non-aqueous phase liquid may be in the Pond 1 sediment. High concentrations of total benzene, ethylbenzene, toluene, and

xylenes (BTEX) in Pond 1 sediments also indicates Pond 1 sediments as a possible groundwater source of volatile aromatic hydrocarbons.

Results of shallow sediment samples from Pond 2 do not indicate it as a source for volatile organic compounds at the Dump Road Area. Additional shallow sediment samples and deeper sediment samples will need to be collected from Pond 2 to eliminate Pond 2 as a possible source area. At present, the hydraulic connection between Pond 1 and groundwater has not been determined, but a study to assess the interconnection between Pond 1 and shallow groundwater is planned.

Trichloroethene equivalent and trichloroethene concentrations in groundwater also indicate the possible presence of dense non-aqueous-phase liquids in the surficial aquifer in the northern portion of the site (wells DMW-9S, MW-18I, DMW-3I, and DMW-2A), in the west–central portion of the site (wells DMW-11S, PA-7, and DMW-1A), and in the southern portion of the site (DA-1, DA-3, DA-5, DA-6, DA-7, DA-8, MIP-28, and pre-2004 results for wells DMW-7S and DMW-5S). High concentrations of total benzene, ethylbenzene, toluene, and xylenes in soil at the Petroleum Hydrocarbon Area northwest of DMW-9S/I/D indicate this area as a significant source of volatile aromatic hydrocarbons. Oily sheens observed at soil boring B-15 and in test pit A33 also indicate that light non-aqueous phase liquids may be in the Petroleum Hydrocarbon Area. High concentrations of benzene, toluene, ethylbenzene, and xylenes have also been detected in soil in the Taxiway Tango Median Area. Groundwater concentrations of benzene, toluene, ethylbenzene, and xylenes are primarily in the upper surficial aquifer zone and appear to be attenuating before reaching the eastern boundary of the Dump Road Area.

5.2 RECOMMENDATIONS

A work plan should be developed to address data gaps, further delineate the extent of possible source areas, and collect data to support the evaluation of source area treatment technologies in a feasibility study. Additional sediment, soil, and groundwater sampling are recommended to fill data gaps in many of the identified trichloroethene and benzene, toluene, ethylbenzene, and xylenes source areas. The following future tasks are recommended to address volatile organic compound source areas in the Dump Road Area:

 Additional samples of Pond 1 and Pond 2 sediment are recommended to evaluate the current concentrations of volatile organic compounds at locations last sampled in 2005, as well as to provide additional chemical data for portions of the ponds not previously sampled. Results of shallow sediment samples from Pond 2 do not indicate Pond 2 as a source for volatile organic compounds. However, sampling has been limited and additional shallow sediment samples and deeper sediment samples need to be collected from Pond 2 before it can be eliminated as a possible source area. Because dense non-aqueous phase liquids (i.e., solvent product) may have migrated to deeper portions of the pond sediment and petroleum hydrocarbons are likely in shallow sediments, sediment samples should be collected at two or more depths to provide vertical profiling of possible contaminants.

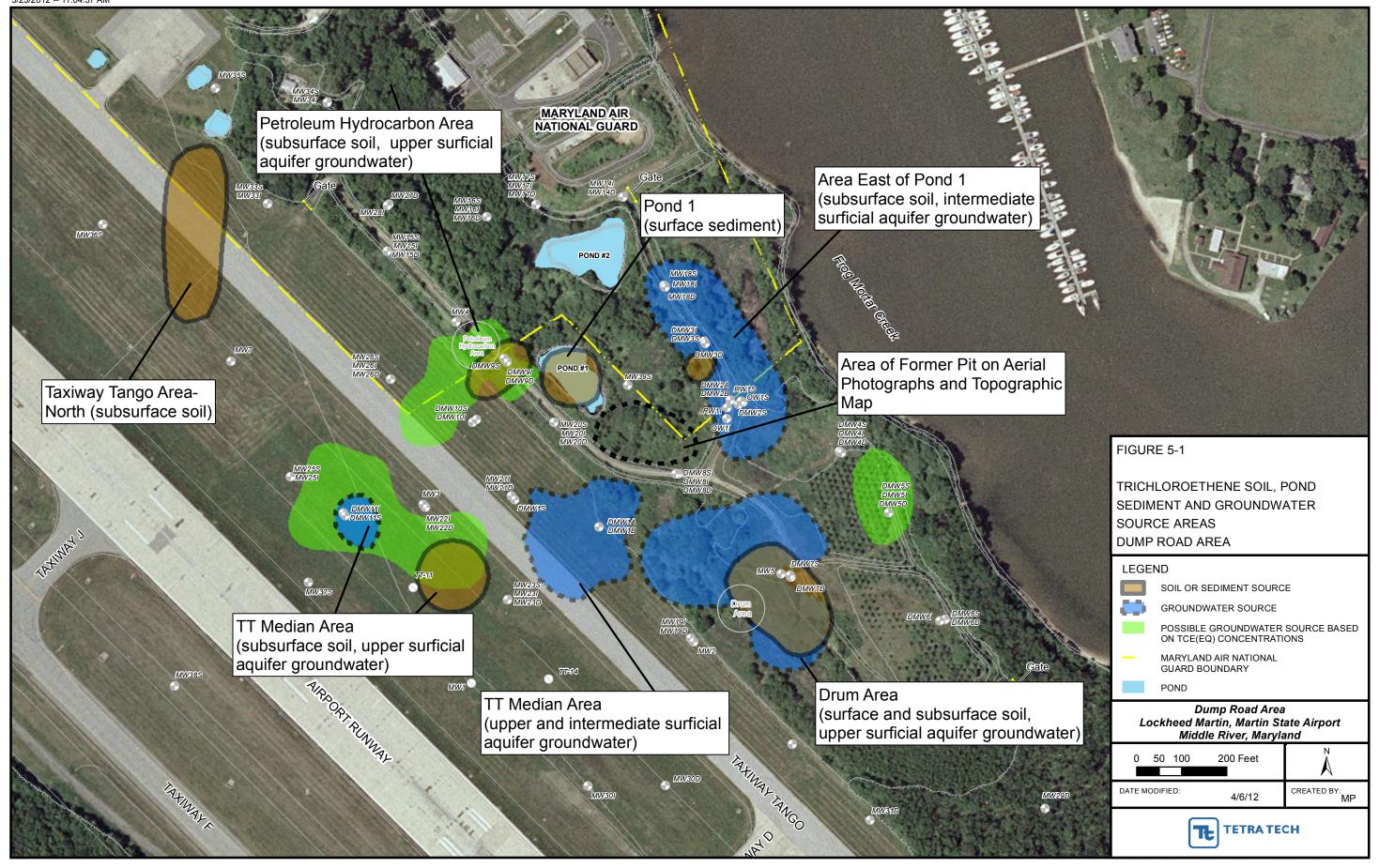
- A hydraulic study is recommended to evaluate the connection between the ponds and underlying groundwater. The study is necessary to assess whether contaminants in the pond sediment have leached into underlying soil and groundwater.
- Additional soil and groundwater sampling are required in the source areas of the Taxiway Tango Median Anomaly Area, Petroleum Hydrocarbon Area, Drum Area, Taxiway Tango Area—North, as well as areas east of Pond 1 and east of wells DMW-18S/I/D, DMW-3S/I/D, DMW-4S/I/D, and DMW-5S/I/D. Much of these data are unevenly distributed and are several years to nearly 10 years old. To optimally locate groundwater monitoring wells, characterize soil and groundwater source areas, and plan for potential remedial options, full soil and groundwater delineations of volatile organic compound source areas are recommended in these areas. Samples should be collected at locations along regularly spaced grids placed over the listed areas. Theissen polygons or an offset grid pattern are recommended. Grid boundaries should be established to overlap known areas of clean soil and groundwater, to minimize additional future rounds of sampling.

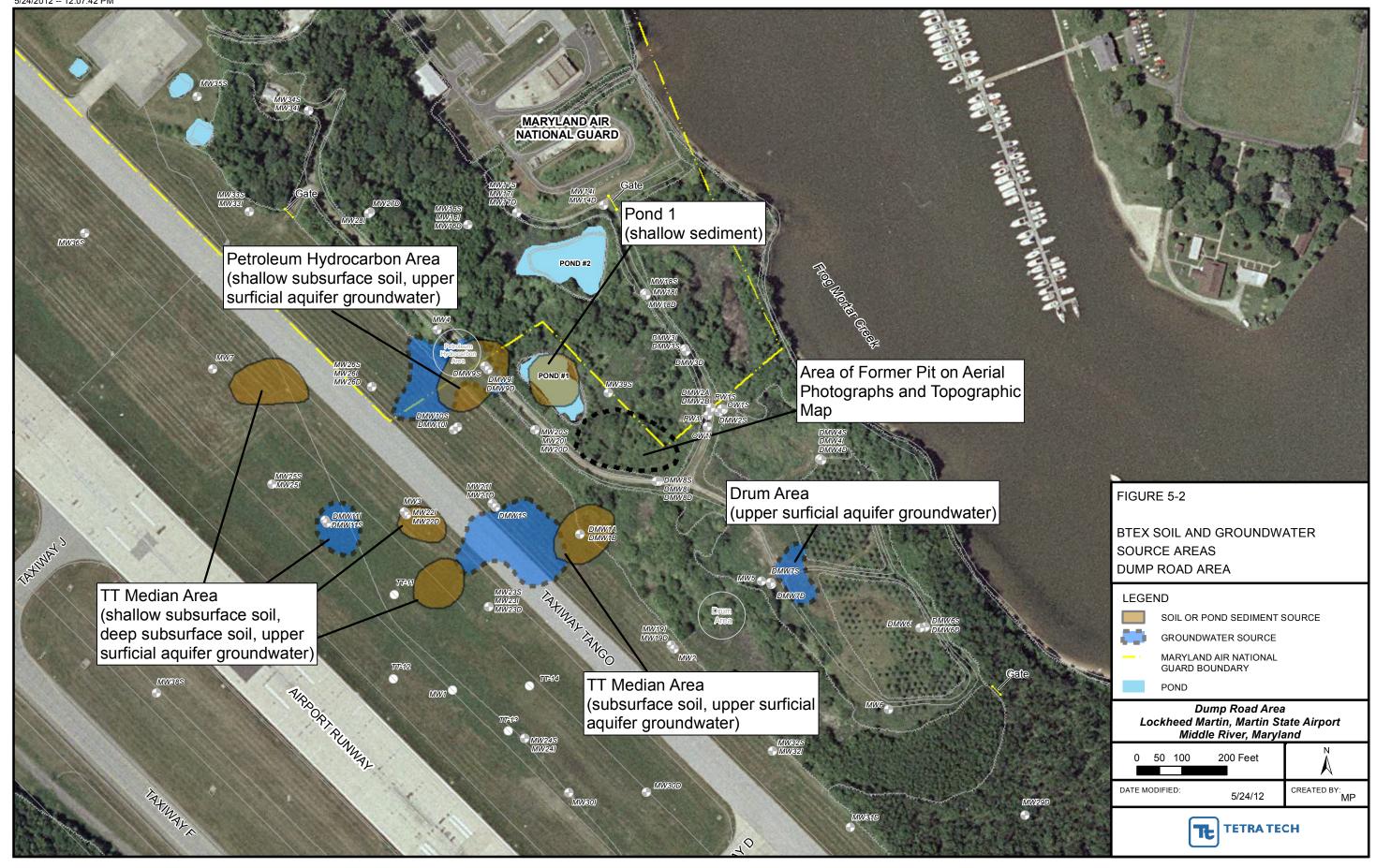
At least two soil samples above the water table and a minimum of three groundwater samples should be collected at each boring using direct push technology probe samplers or sonic drilling techniques. Dual wall direct-push samplers or multi-casing sonic rig configurations must be used to seal off the upper contaminated zones and eliminate potential contaminant migration to deeper portions of the subsurface. For efficiency, samples should only be collected for volatile organic compounds. Sampling will provide vertical chemical profiles in soil and groundwater, which will allow characterization of volatile organic compounds in three dimensions at the site. Other analyses, such as for semivolatile organic compounds or metals, could be performed on subsets of samples based on data needs established for those analytes.

- Additional soil and groundwater sampling is recommended for the area between the southern end of Pond 1 and wells DMW-8S/I/D. This is the area shown as a third pond and possible acid pit on a U.S. Geological Survey topographic map used during the 1989 preliminary assessment. Groundwater samples should be collected at regular intervals using direct-push technology or a sonic rig to the base of the surficial aquifer to provide a complete contaminant profile for the area.
- Additional subsurface soil sampling is required in the Drum Area to fully characterize chlorinated volatile organic compounds in shallow subsurface and deep soil. The extent of elevated TCE levels in surface soil here have not yet been delineated, particularly north and west of samples DA-NC-1-1 and DA-NC2-1, north and east of DA T3-1-2, east of samples DA-ES1-1 and DA-ES3-1, and south of DA-T2-5-2.

- Installation of upper and intermediate surficial-aquifer wells at locations DA-7, DA-8, DA-3, and DA-2 in the Drum Area is recommended. DA-7 contained the highest concentration of trichloroethene (130,000 micrograms per liter) at the Drum Area, and DA-8 and DA-3 had high concentrations of trichloroethene, indicating dense non-aqueous phase liquids in other portions of the Drum Area. The DA samples only provide a groundwater sample from one depth. Upper and intermediate wells will provide chemical data for two depths in the source area. Wells at DA-8, and DA-3 will provide additional monitoring locations within the source area. A well at DA-2 will provide water quality conditions upgradient of the source area. Wells at these locations are required to identify/verify the current volatile organic compound concentrations in this possible source area, to provide wells for long-term monitoring of site contaminants, and to provide water-quality data to evaluate and execute potential remedial measures. Additionally, these wells will provide lithologic information to further characterize the thin sand layer of the upper surficial aquifer and underlying clay aquitard.
- Installation of an upper surficial aquifer (or "S") well is recommended at sampling location PA-7. PA-7 contained the highest concentration of trichloroethene (220,000 micrograms per liter) at the Dump Road Area at 15 feet below grade. The current wells near DA-7 are DMW-1A and DMW-1B are screened below the PA-7 sampling interval in the intermediate and lower surficial aquifer at 45–55 feet below grade (DMW-1A) and 83–88 feet below grade (DMW-1B). An upper surficial aquifer well at this location is needed to identify/verify the current volatile organic compound concentrations in this possible source area, to provide a well for long-term monitoring of site contaminants, and to provide water-quality data to evaluate and execute potential remedial measures.
- Additional soil and groundwater sampling is also recommended east of Pond 1, between
 the edge of the pond to well DMW-3S/I/D; additional lithologic and chemical data are
 required for this area to confirm the possible lithologic and hydraulic connection between
 DMW-9S and DMW-3I.

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Section 6 References

- 1. Chapelle, F. M., 1985. "Hydrogeology, Digital Solute-Transport Simulation, and Geochemistry of the Lower Cretaceous Aquifer System near Baltimore, Maryland." *Maryland Geological Survey Report of Investigations No. 43*. Maryland Geological Survey, Baltimore, Maryland. 120 pp.
- 2. Curtin, S., 2006. Personal communication and draft potentiometric map of the Patuxent Aquifer—2004. Mr. Fred Kolberg of Tetra Tech with Mr. Steve Curtin of the U.S. Geological Survey, Baltimore, Maryland. May 5.
- 3. Glaser, J. D., 1969. "Petrology and Origin of Potomac and Magothy (Cretaceous) Sediments, Middle Atlantic Coastal Plain, Maryland." *Geological Survey Reports of Investigations No. 11*. Maryland Geological Survey, Baltimore, Maryland. 102 pp.
- 4. Handex Environmental Management, 1992. *Geophysical Survey Report, Taxiway Tango, Martin State Airport, Middle River, Maryland.* Prepared for Maryland Aviation Administration, Baltimore-Washington International Airport, Maryland by Handex Environmental Management, Inc. Morganville, New Jersey. February.
- 5. Hansen, H. J., and J. Edwards, 1986. "The Lithology and Distribution of Pre-Cretaceous Basement Rocks beneath the Maryland Coastal Plain." *Maryland Geological Survey Report of Investigations*. 44, 27 p.
- 6. Kueper, B. H., and K. Davies, 2009. *Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites*. EPA/600/R-09/119, U.S. Environmental Protection Agency, National Risk Management Research Laboratory, Cincinnati, Ohio. www.epa.gov/nrmrl/pubs/600r09119/600r09119.pdf. September.
- 7. MAA (Maryland Aviation Administration), 2008. *Spill Prevention, Control, and Countermeasure Plan for Martin State Airport.* Prepared for MAA, Facilities Development and Engineering, Linthicum, Maryland by EA Engineering, Science, and Technology, Inc. Sparks, Maryland. December.
- 8. MDE (Maryland Department of the Environment), 1989. *Final Report, a Preliminary Assessment of Martin State Airport, Middle River, Maryland (MD-304)*. Prepared by Maryland Hazardous and Solid Waste Management Administration, Maryland Department of the Environment, Baltimore, Maryland for the U.S. Environmental Protection Agency, Region III, Philadelphia, Pennsylvania. March.
- 9. MDE (Maryland Department of the Environment), 1992. Letter dated January 6, 1997 from Ms. Arlene G. Weiner, MDE, Baltimore Maryland to Maryland Aviation Administration: "Subsurface Investigations," Martin State Airport, Middle River, Maryland. January.

- 10. MDE (Maryland Department of the Environment), 1997. Letter dated January 24, 1997 from Mr. Arthur O'Connell, MDE to the Maryland Aviation Administration, Martin State Airport, Middle River, Maryland. January.
- 11. MDE (Maryland Department of the Environment), 1998. Memorandum: "Frog Mortar Creek/Surface Water and Sediment Data" from Mr. Michael Sivak, Maryland Department of the Environment, Waste Management Administration, to Ms. Peggy Smith, Maryland Department of the Environment, Waste Management Administration. August 20.
- 12. MDE (Maryland Department of the Environment), 2008. *Cleanup Standards for Soil and Groundwater.* Interim Final. Update No. 2.1. June.
- 13. MES (Maryland Environmental Service), 1994. *Martin State Airport Preliminary Site Investigation of the Taxiway Tango, Martin State Airport, Middle River, Maryland*. Report prepared by MES, Annapolis, Maryland for the Maryland Aviation Administration, Baltimore, Maryland. May.
- 14. MES (Maryland Environmental Service), 1995. Martin State Airport Confirmation Investigation—Continuation of Phase I Taxiway Tango Site Investigation, Martin State Airport, Middle River, Maryland. Report prepared by MES, Annapolis, Maryland for the Maryland Aviation Administration, Baltimore, Maryland. January.
- 15. MES (Maryland Environmental Service), 1996. *Martin State Airport Expanded Investigation—Continuation of Phase I Taxiway Tango Site Investigation, Martin State Airport, Middle River, Maryland*. Report prepared by MES, Annapolis, Maryland for the Maryland Aviation Administration, Baltimore, Maryland. July.
- 16. Tetra Tech (Tetra Tech, Inc.), 1999. Final Groundwater Monitoring Well Surveying and Sampling Report Martin State Airport, Middle River, Maryland. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. May.
- 17. Tetra Tech (Tetra Tech, Inc.), 2000. Final Source Identification and Assessment Report, Martin State Airport, Middle River, Maryland. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. September.
- 18. Tetra Tech (Tetra Tech, Inc.), 2002. *Chemical Delineation and Groundwater Modeling Report*. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. December.
- 19. Tetra Tech (Tetra Tech, Inc.), 2004a. *Final Data-Gap Investigation and Modeling Report*. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. May.
- 20. Tetra Tech (Tetra Tech, Inc.), 2004b. *Final December 2003 Quarterly Groundwater Monitoring Report, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. May.

- 21. Tetra Tech (Tetra Tech, Inc.), 2004c. *Final March 2004 Quarterly Groundwater Monitoring Report, Martin State Airport, Middle River, Maryland.* Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. June.
- 22. Tetra Tech (Tetra Tech, Inc.), 2004d. *Revised Final June 2004 Quarterly Groundwater Monitoring Report, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. September.
- 23. Tetra Tech (Tetra Tech, Inc.), 2004e. *Final September 2004 Quarterly Groundwater Monitoring Report, Martin State Airport, Middle River, Maryland.* Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. November.
- 24. Tetra Tech (Tetra Tech, Inc.), 2005a. Final December 2004 Quarterly Groundwater Monitoring Report, Martin State Airport, Middle River, Maryland. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. March.
- 25. Tetra Tech (Tetra Tech, Inc.), 2005b. *Groundwater User Survey Technical Memorandum, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. April.
- 26. Tetra Tech (Tetra Tech, Inc.), 2005c. *Additional Soil and Sediment Sampling Letter Report, Martin State Airport, Middle River, Maryland (MD-304)*. Letter report to Ms. Peggy Smith, Maryland Department of the Environment, Baltimore, Maryland. Prepared by Tetra Tech, Inc., Pasadena, California for Lockheed Martin, Bethesda, Maryland. July 29.
- 27. Tetra Tech (Tetra Tech, Inc.), 2008. *Soil and Groundwater Data Report, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. June.
- 28. Tetra Tech (Tetra Tech, Inc.), 2009a. *Deep Groundwater Investigation Report, Lockheed Martin, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. April.
- 29. Tetra Tech (Tetra Tech, Inc.), 2009b. *Groundwater Monitoring Report, August–September 2008. Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. May.
- 30. Tetra Tech (Tetra Tech, Inc.), 2010a. *Groundwater Monitoring Report, August–September 2009, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. January.
- 31. Tetra Tech (Tetra Tech, Inc.), 2010b. *Technical Memorandum: Off-Site Piezometer Installation and Water-Level Monitoring Report, Martin State Airport, Middle River, Maryland.* Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. November.

- 32. Tetra Tech (Tetra Tech, Inc.), 2010c. *Groundwater Monitoring Report July 2010, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland.* Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. December.
- 33. Tetra Tech (Tetra Tech, Inc.), 2011a. *Dump Road Supplemental Design Characterization Report, Martin State Airport, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. April.
- 34. Tetra Tech (Tetra Tech, Inc.), 2011b. *Technical Memorandum: Dump Road Area, Frog Mortar Creek and Off-Site Continuous Water-Level Report, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. October.
- 35. Tetra Tech (Tetra Tech, Inc.), 2012a. *Remedial Investigation Report, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. April.
- 36. Tetra Tech (Tetra Tech, Inc.), 2012b. 2011 Surface Water Sampling Report for Frog Mortar Creek, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. March.
- 37. Tetra Tech (Tetra Tech, Inc.), 2012c. *Groundwater Use Investigation Report, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. March.
- 38. Tetra Tech (Tetra Tech, Inc.), 2012d. 2011 *Groundwater Monitoring Report, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. March.
- 39. Tetra Tech (Tetra Tech, Inc.), 2012e. *Compass Rose Area Soil Investigation Report, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. March.
- 40. Tetra Tech (Tetra Tech, Inc.), 2012f. Dump Road and Runway Area Soil and Groundwater Investigation, Martin State Airport, 701 Wilson Point Road, Middle River, Maryland. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin, Bethesda, Maryland. January.
- 41. Vroblesky, D. A. and W. B. Fleck, 1991. "Hydrogeologic Framework of the Coastal Plain of Maryland, Delaware, and the District of Columbia, Regional Aquifer System Analysis—Northern Atlantic Coastal Plain." *U.S. Geological Survey Professional Paper 1404-E.* U.S. Government Printing Office, Washington, D.C. 45 pp.

APPENDIX A—STUDY DATA

BTEX GW Original

				2009	2010	2011	
sample_id	sample_date	easting	northing	BTEX	BTEX	BTEX	
DMW1A	20090904	1479498.31	604398.93	220	82	110	I
DMW1B	20090904	1479498.68	604399.15	0	0	15	D
DMW1S	20090908	1479310.93	604458.71	1.4	5	1.7	S
DMW2A	20090903	1479789.18	604678.89	0	0	0	I
DMW2S	20090901	1479807.82	604670.26	0	0	9.3	S
DMW3D	20090908	1479731.58	604810.35	0	0	0	D
DMW3I	20090903	1479731.67	604810.23	0	0	0	ı
DMW3S	20090903	1479731.67	604810.23	0	23	28	S
DMW4D	20090903	1480030.83	604566.02	0	0	0	D
DMW4I	20090901	1480031.07	604565.89	0	0	0	ı
DMW4S	20090903	1480035.76	604562.77	0	0	0	S
DMW5I	20090908	1480140.5	604419.87	0.35	0	0	I
DMW5S	20090903	1480141.08	604415.6	0	0	0	S
DMW6D	20090903	1480266.04	604193.88	0	0	0	D
DMW6I	20090903	1480265.8	604193.89	0	0	0	ı
DMW6S	20090903	1480255.25	604190.24	0	0	0	S
DMW8D	20090902	1479673.19	604516.37	0	0	0	D
DMW8I	20090902	1479673.3	604516.63	0	0	3.5	I
DMW8S	20090902	1479667.65	604517.11	0	0	0	S
DMW9D	20090902	1479293.89	604764.94	0	0	24	D
DMW9I	20090902	1479293.73	604764.96	23	0	20	ı
DMW9S	20090902	1479287.27	604771.52	30170	23610	22990	S
MW03	20090908	1479107.13	604448.6	0	0	0	S
MW04	20090908	1479180.77	604852.95	2.2	0.6	0	S
MW05	20090908	1479901.65	604294.92	0	0	0	S
MW06	20090908	1480185.27	604009.29	0	0	0	S
MW10S	20090904	1479225.84	604636.66	1.5	0	0	S
MW11I	20090908	1478934.94	604423.96	0	0	0	I
MW11S	20090908	1478930.78	604429.32	1600	1800	730	S
MW14D	20090908	1479550.682	605129.8548	0	0	0	D
MW14I	20090908	1479550.682	605129.8548	11	0	5.5	I
MW15D	20090825	1479028.294	605010.9613	0	0	0	D
MW15I	20090826	1479028.294	605010.9613	0	0	0	ı
MW15S	20090825	1479028.294	605010.9613	0	0	0	S

BTEX GW Original

				2009	2010	2011	
sample_id	sample_date	easting	northing	BTEX	BTEX	BTEX	
MW16D	20090827	1479248.844	605086.4229	0	0	0	D
MW16I	20090826	1479248.844	605086.4229	0	0	0.64	ı
MW16S	20090826	1479248.844	605086.4229	2.6	3.3	7.7	S
MW17I	20090828	1479358.318	605112.6691	0	0	0	I
MW17S	20090828	1479358.318	605112.6691	0	0	0	S
MW18I	20090901	1479645.061	604930.7721	0	0	0	I
MW18S	20090901	1479645.061	604930.7721	0	0	0	S
MW19D	20090901	1479701.179	604152.7014	0	0	0	D
MW19I	20090901	1479701.179	604152.7014	0	0	1.1	I
MW20D	20090827	1479397.945	604630.9616	0	0	0	D
MW20I	20090827	1479397.945	604630.9616	0	0	2	I
MW20S	20090826	1479397.945	604630.9616	80	62	66.8	S
MW22D	20090831	1479112.839	604442.0743	0	0	0	D
MW23D	20090831	1479295.124	604237.1317	0	0	0	D
MW23S	20090831	1479295.124	604237.1317	2.1	1.5	3.2	S
MW24I	20090901	1479375.239	603945.6639	0	0	0	I
MW24S	20090901	1479375.239	603945.6639	0	0.22	0	S
MW25I	20090831	1478812.441	604510.0829	0	0	0	I
MW25S	20090831	1478812.441	604510.0829	0	0	0	S
MW26S	20090831	1479035.393	604726.4128	12	14	17	S
MW27D	20090828	1479032	605114.25	0	0	0	DD
MW28I	20090826	1479027.89	605110.61	0	0	7.8	I
MW29D	20090903	1480488.41	603774.77	0	0	0	DD
MW30D	20090901	1479645.71	603825.46	0	0	0	DD
MW-30D	20090114	1479645.71	603825.46	0.58			DD
MW31D	20090828	1480099.58	603747.78	0	0	0	DD
MW-31D	20090114	1480099.58	603747.78	2.05			DD
MW32I	20090904	1479930.711	603917.9149	1.8	0	0	I
MW32S	20090904	1479930.711	603917.9149	0	0	0	S
MW33I	20090904	1478763.31	605117.6822	0.3	0	0	I
MW33S	20090904	1478763.31	605117.6822	36	29.1	0	S
MW34I	20090904	1478890.17	605355.017	22.2	18.13	11.1	I
MW34S	20090904	1478890.17	605355.017	0	0	0.17	S
MW-35S	2011	1478645.770	605371.560			2.4	S

BTEX GW Original

				2009	2010	2011	
sample_id	sample_date	easting	northing	BTEX	BTEX	BTEX	
MW-36S	2011	1478395.880	605068.520			0	S
MW-37S	2011	1478851.690	604275.330			0	S
MW-38S	2011	1478555.270	604045.940			0	S
MW-39S	2011	1479561.570	604711.980			4.89	S
MW10I	20080815	1479217.23	604630.66	0	0	0	I
MW17D	20080905	1479358.318	605112.6691	0.42	0.42	0.42	D
MW18D	20080902	1479642.312	604934.535	0	0	0	D
MW21D	20080808	1479303.217	604467.7476	9.2	9.2	9.2	D
MW21I	20080808	1479303.217	604467.7476	4.65	4.65	4.65	I
MW22I	20080818	1479112.839	604442.0743	8.2	8.2	8.2	I
MW-23I	20080818	1479295.124	604237.1317	22.8	22.8	22.8	I
MW26D	20080807	1479035.393	604726.4128	0	0	0	D
MW26I	20080807	1479035.393	604726.4128	4.38	4.38	4.38	I
MW2B	20080829	1479789.14	604678.66	0	0	0	D
DMW5D	20080821	1480140.63	604420.15	0	0	0	D
DMW7D	20080828	1479924.33	604286.92	0.59	0.59	0.59	D
DMW7I	20080828	1479924.17	604287.19	0.73	0.73	0.73	-
DMW7S	2007	1479921.81	604291.49	131	131	131	S
MW30I	2011	1479473.540000	603824.910000			0	I

BTEX GW sorted

				2009	2010	2011	
sample_id	sample_date	easting	northing	BTEX	BTEX	BTEX	
DMW1S	20090908	1479310.93	604458.71	1.4	5	1.7	S
DMW2S	20090901	1479807.82	604670.26	0	0	9.3	S
DMW3S	20090903	1479731.67	604810.23	0	23	28	S
DMW4S	20090903	1480035.76	604562.77	0	0	0	S
DMW5S	20090903	1480141.08	604415.6	0	0	0	S
DMW6S	20090903	1480255.25	604190.24	0	0	0	S
DMW7S	2007	1479921.81	604291.49	131	131	131	S
DMW8S	20090902	1479667.65	604517.11	0	0	0	S
DMW9S	20090902	1479287.27	604771.52	30170	23610	22990	S
MW03	20090908	1479107.13	604448.6	0	0	0	S
MW04	20090908	1479180.77	604852.95	2.2	0.6	0	S
MW05	20090908	1479901.65	604294.92	0	0	0	S
MW06	20090908	1480185.27	604009.29	0	0	0	S
MW10S	20090904	1479225.84	604636.66	1.5	0	0	S
MW11S	20090908	1478930.78	604429.32	1600	1800	730	S
MW15S	20090825	1479028.294	605010.9613	0	0	0	S
MW16S	20090826	1479248.844	605086.4229	2.6	3.3	7.7	S
MW17S	20090828	1479358.318	605112.6691	0	0	0	S
MW18S	20090901	1479645.061	604930.7721	0	0	0	S
MW20S	20090826	1479397.945	604630.9616	80	62	66.8	S
MW23S	20090831	1479295.124	604237.1317	2.1	1.5	3.2	S
MW24S	20090901	1479375.239	603945.6639	0	0.22	0	S
MW25S	20090831	1478812.441	604510.0829	0	0	0	S
MW26S	20090831	1479035.393	604726.4128	12	14	17	S
MW32S	20090904	1479930.711	603917.9149	0	0	0	S
MW33S	20090904	1478763.31	605117.6822	36	29.1	0	S
MW34S	20090904	1478890.17	605355.017	0	0	0.17	S
MW-35S	2011	1478645.770	605371.560			2.4	S
MW-36S	2011	1478395.880	605068.520			0	S
MW-37S	2011	1478851.690	604275.330			0	S
MW-38S	2011		604045.940			0	S
MW-39S	2011	1479561.570	604711.980			4.89	S
DMW1A	20090904	1479498.31	604398.93	220	82	110	I

BTEX GW sorted

				2009	2010	2011	
sample_id	sample_date	•	northing	BTEX	BTEX	BTEX	
DMW2A	20090903	1479789.18	604678.89	0	0	0	I
DMW3I	20090903	1479731.67	604810.23	0	0	0	I
DMW4I	20090901	1480031.07	604565.89	0	0	0	I
DMW5I	20090908	1480140.5	604419.87	0.35	0	0	1
DMW6I	20090903	1480265.8	604193.89	0	0	0	1
DMW7I	20080828	1479924.17	604287.19	0.73	0.73	0.73	I
DMW8I	20090902	1479673.3	604516.63	0	0	3.5	I
DMW9I	20090902	1479293.73	604764.96	23	0	20	I
MW10I	20080815	1479217.23	604630.66	0	0	0	I
MW11I	20090908	1478934.94	604423.96	0	0	0	I
MW14I	20090908	1479550.682	605129.8548	11	0	5.5	I
MW15I	20090826	1479028.294	605010.9613	0	0	0	1
MW16I	20090826	1479248.844	605086.4229	0	0	0.64	I
MW17I	20090828	1479358.318	605112.6691	0	0	0	1
MW18I	20090901	1479645.061	604930.7721	0	0	0	1
MW19I	20090901	1479701.179	604152.7014	0	0	1.1	1
MW20I	20090827	1479397.945	604630.9616	0	0	2	1
MW21I	20080808	1479303.217	604467.7476	4.65	4.65	4.65	I
MW22I	20080818	1479112.839	604442.0743	8.2	8.2	8.2	1
MW-23I	20080818	1479295.124	604237.1317	22.8	22.8	22.8	I
MW24I	20090901	1479375.239	603945.6639	0	0	0	1
MW25I	20090831	1478812.441	604510.0829	0	0	0	I
MW26I	20080807	1479035.393	604726.4128	4.38	4.38	4.38	1
MW28I	20090826	1479027.89	605110.61	0	0	7.8	I
MW30I	2011	1479473.540000	603824.910000			0	1
MW32I	20090904	1479930.711	603917.9149	1.8	0	0	I
MW33I	20090904	1478763.31	605117.6822	0.3	0	0	I
MW34I	20090904	1478890.17	605355.017	22.2	18.13	11.1	I
MW27D	20090828	1479032	605114.25	0	0	0	DD
MW29D	20090903	1480488.41	603774.77	0	0	0	DD
MW30D	20090901	1479645.71	603825.46	0	0	0	DD
MW-30D	20090114	1479645.71	603825.46	0.58			DD
MW31D	20090828	1480099.58	603747.78	0	0	0	DD

BTEX GW sorted

				2009	2010	2011	
sample_id	sample_date	easting n	orthing	BTEX	BTEX	BTEX	
MW-31D	20090114	1480099.58	603747.78	2.05			DD
DMW1B	20090904	1479498.68	604399.15	0	0	15	D
DMW2B	20080829	1479789.14	604678.66	0	0	0	D
DMW3D	20090908	1479731.58	604810.35	0	0	0	D
DMW4D	20090903	1480030.83	604566.02	0	0	0	D
DMW5D	20080821	1480140.63	604420.15	0	0	0	D
DMW6D	20090903	1480266.04	604193.88	0	0	0	D
DMW7D	20080828	1479924.33	604286.92	0.59	0.59	0.59	D
DMW8D	20090902	1479673.19	604516.37	0	0	0	D
DMW9D	20090902	1479293.89	604764.94	0	0	24	D
MW14D	20090908	1479550.682	605129.8548	0	0	0	D
MW15D	20090825	1479028.294	605010.9613	0	0	0	D
MW16D	20090827	1479248.844	605086.4229	0	0	0	D
MW17D	20080905	1479358.318	605112.6691	0.42	0.42	0.42	D
MW18D	20080902	1479642.312	604934.535	0	0	0	D
MW19D	20090901	1479701.179	604152.7014	0	0	0	D
MW20D	20090827	1479397.945	604630.9616	0	0	0	D
MW21D	20080808	1479303.217	604467.7476	9.2	9.2	9.2	D
MW22D	20090831	1479112.839	604442.0743	0	0	0	D
MW23D	20090831	1479295.124	604237.1317	0	0	0	D
MW26D	20080807	1479035.393	604726.4128	0	0	0	D

MSA-BTEX-GW 2011S

1479310.93	604458.71	1.7
1479807.82	604670.26	9.3
1479731.67	604810.23	28
1480035.76	604562.77	0
1480141.08	604415.6	0
1480255.25	604190.24	0
1479921.81	604291.49	131
1479667.65	604517.11	0
1479287.27	604771.52	22990
1479107.13	604448.6	0
1479180.77	604852.95	0
1479901.65	604294.92	0
1480185.27	604009.29	0
1479225.84	604636.66	0
1478930.78	604429.32	730
1479028.294	605010.9613	0
1479248.844	605086.4229	7.7
1479358.318	605112.6691	0
1479645.061	604930.7721	0
1479397.945	604630.9616	66.8
1479295.124	604237.1317	3.2
1479375.239	603945.6639	0
1478812.441	604510.0829	0
1479035.393	604726.4128	17
1479930.711	603917.9149	0
		0
		0.17
		2.4
		0
1478851.690	604275.330	0
		0
1479561.570	604711.980	4.89
	1479807.82 1479731.67 1480035.76 1480141.08 1480255.25 1479921.81 1479667.65 1479287.27 1479107.13 1479180.77 1479901.65 1480185.27 1479225.84 1478930.78 1479028.294 1479248.844 1479358.318 1479645.061 1479397.945 1479295.124 1479375.239 1478812.441 1479035.393 1479930.711 1478763.31 1478890.17 1478645.770 1478395.880	1479807.82 604670.26 1479731.67 604810.23 1480035.76 604562.77 1480141.08 604415.6 1480255.25 604190.24 1479921.81 604291.49 1479667.65 604517.11 1479287.27 604771.52 1479107.13 604448.6 1479180.77 604852.95 1479901.65 604294.92 1480185.27 604009.29 1479225.84 604636.66 1479028.294 605010.9613 1479248.844 605086.4229 1479358.318 605112.6691 1479397.945 604630.9616 1479295.124 604237.1317 1479375.239 603945.6639 1478812.441 604510.0829 1479035.393 604726.4128 1479930.711 603917.9149 1478890.17 605355.017 1478845.770 605371.560 1478851.690 604045.940 1478555.270 604045.940

MSA-BTEX-GW 2011I

DMW1A	1479498.31	604398.93	110
DMW2A	1479789.18	604678.89	0
DMW3I	1479731.67	604810.23	0
DMW4I	1480031.07	604565.89	0
DMW5I	1480140.5	604419.87	0
DMW6I	1480265.8	604193.89	0
DMW7I	1479924.17	604287.19	0.73
DMW8I	1479673.3	604516.63	3.5
DMW9I	1479293.73	604764.96	20
MW10I	1479217.23	604630.66	0
MW11I	1478934.94	604423.96	0
MW14I	1479550.682	605129.8548	5.5
MW15I	1479028.294	605010.9613	0
MW16I	1479248.844	605086.4229	0.64
MW17I	1479358.318	605112.6691	0
MW18I	1479645.061	604930.7721	0
MW19I	1479701.179	604152.7014	1.1
MW20I	1479397.945	604630.9616	2
MW21I	1479303.217	604467.7476	4.65
MW22I	1479112.839	604442.0743	8.2
MW-23I	1479295.124	604237.1317	22.8
MW24I	1479375.239	603945.6639	0
MW25I	1478812.441	604510.0829	0
MW26I	1479035.393	604726.4128	4.38
MW28I	1479027.89	605110.61	7.8
MW30I	1479473.540000	603824.910000	0
MW32I	1479930.711	603917.9149	0
MW33I	1478763.31	605117.6822	0
MW34I	1478890.17	605355.017	11.1

MSA-BTEX-GW-2011D

DMW1B	1479498.68	604399.15	15
DMW2B	1479789.14	604678.66	0
DMW3D	1479731.58	604810.35	0
DMW4D	1480030.83	604566.02	0
DMW5D	1480140.63	604420.15	0
DMW6D	1480266.04	604193.88	0
DMW7D	1479924.33	604286.92	0.59
DMW8D	1479673.19	604516.37	0
DMW9D	1479293.89	604764.94	24
MW14D	1479550.682	605129.8548	0
MW15D	1479028.294	605010.9613	0
MW16D	1479248.844	605086.4229	0
MW17D	1479358.318	605112.6691	0.42
MW18D	1479642.312	604934.535	0
MW19D	1479701.179	604152.7014	0
MW20D	1479397.945	604630.9616	0
MW21D	1479303.217	604467.7476	9.2
MW22D	1479112.839	604442.0743	0
MW23D	1479295.124	604237.1317	0
MW26D	1479035.393	604726.4128	0

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 1 OF 14

SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION: VOLATILES (ug/l)	6/1/2011	DMW1B-060111 240-690-5 6/1/2011 DMW1B	DMW1S-060111 240-690-6 6/1/2011 DMW1S	DMW2A-060711 240-906-4 6/7/2011 DMW2A	DMW2S-060711 240-906-2 6/7/2011 DMW2S	MW3-060911 240-979-5 6/9/2011 MW3	DMW3D-060711 240-906-3 6/7/2011 DMW3D
CIS-1,2-DICHLOROETHENE	6600	2400	65	3700	1200	10	
TRICHLOROETHENE	5000	560	15	13000	2700	0.83 J	4.7
VINYL CHLORIDE	1400	1800	27	850	520	1.7	
Y1	6.80412E-05	2.47423E-05	6.70103E-07	3.81443E-05	1.23711E-05	1.03093E-07	0
Y2	3.80228E-05	4.25856E-06	1.14068E-07	9.88593E-05	2.05323E-05	6.31179E-09	3.57414E-08
Y3	0.0000224	0.0000288	0.000000432	0.0000136	0.00000832	2.72E-08	0
Z - TCE Equivalent in ug/L	16893.02	7600.81	159.93	19804.38	5420.88	17.96	4.70

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 2 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:		DMW3S-060911 240-979-8 6/9/2011 DMW3S	MSA-MW4-052611 240-569-2 5/26/2011 MSA-MW4	DMW4A-060711 R1103194-004 6/7/2011 DMW4A	DMW4D-053111 240-626-6 5/31/2011 DMW4D	DMW4I-053111 240-626-8 5/31/2011 DMW4I	DMW4S-060711 240-906-5 6/7/2011 DMW4S
VOLATILES (ug/l)								
CIS-1,2-DICHLOROETHENE		9200	1000			410	2100	120
TRICHLOROETHENE		12000				4200	2600	1200
VINYL CHLORIDE		3000	2900				1000	32 J
Y1		9.48454E-05	1.03093E-05	0	0	4.2268E-06	2.16495E-05	1.23711E-06
Y2		9.12548E-05	0	0	0	3.19392E-05	1.97719E-05	9.12548E-06
Y3		0.000048	0.0000464	0	0	0	0.000016	0.000000512
Z - TCE Equivalent in ug/L		30784.16	7457.27	0.00	0.00	4755.82	7550.91	1430.01

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011
DUMP ROAD AREA

TABLE 4-3

LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 3 OF 14

VOLATILES (ug/l)	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	MW-5 240-475-3 5/24/2011 MW-5	MW-5-A 240-475-3 5/24/2011 MW-5-A	DMW5I-060811 240-914-4 6/8/2011 DMW5I	DMW5S-060811 240-914-2 6/8/2011 DMW5S	MSA-MW6-052611 240-569-3 5/26/2011 MSA-MW6	MSA-DMW6D- 052511 240-531-2 5/25/2011 MSA-DMW6D	MSA-DMW6I- 052511 240-531-3 5/25/2011 MSA-DMW6I
CIS-1,2-DICHLOROETHENE		2900		54	1500			
TRICHLOROETHENE		51 J		110	9300			
VINYL CHLORIDE		750		6.6				
Y1		2.98969E-05	0	5.56701E-07	1.54639E-05	0	0	0
Y2		3.87833E-07	0	8.36502E-07	7.07224E-05	0	0	0
Y3		0.000012	0	1.056E-07	0	0	0	0
Z - TCE Equivalent in ug/L		5560.44	0.00	197.09	11333.51	0.00	0.00	0.00

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011
DUMP ROAD AREA

LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 4 OF 14

TABLE 4-3

	SAMPLE ID: LABORATORY ID: SAMPLE DATE:	MSA-DMW6S- 052511 240-531-4 5/25/2011	MSA-DMW6S- 052511RA 240-531-4 5/25/2011	DMW-8D 240-475-1 5/24/2011	DMW-8I 240-410-1 5/23/2011	DMW8S-051911 240-321-5 5/19/2011	DMW8S-051911-A 240-321-5 5/19/2011	DMW9D-060611 240-813-9 6/6/2011
	LOCATION:	MSA-DMW6S	MSA-DMW6S	DMW-8D	DMW-8I	DMW8S	DMW8S	DMW9D
VOLATILES (ug/l)								
CIS-1,2-DICHLOROETHENE		1.6		840	540	0.39 J		380
TRICHLOROETHENE		0.53 J		940	740			2800
VINYL CHLORIDE				460	280			43 J
Y1		1.64948E-08	0	8.65979E-06	5.56701E-06	4.02062E-09	0	3.91753E-06
Y2		4.03042E-09	0	7.14829E-06	5.62738E-06	0	0	2.12928E-05
Y3		0	0	0.00000736	0.00000448	0	0	0.000000688
Z - TCE Equivalent in ug/L		2.70	0.00	3046.60	2061.18	0.53	0.00	3405.63

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 5 OF 14

VOLATILES (ug/l)	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	DMW9I-060611 240-813-6 6/6/2011 DMW9I	DMW9S-0060611 R1103161-002 6/6/2011 DMW9S	DMW9S-060611 240-813-3 6/6/2011 DMW9S	DMW10S-060211 240-726-7 6/2/2011 DMW10S	MW11I-060911 240-979-6 6/9/2011 MW11I	MW11S-060911 240-979-4 6/9/2011 MW11S	DMW14D-051911 240-321-3 5/19/2011 DMW14D
CIS-1,2-DICHLOROETHENE		1800		12000		0.45 J	23000	
TRICHLOROETHENE		700		790 J		0.23 J	12000	
VINYL CHLORIDE		830		18000	380		4500	
Y1		1.85567E-05	0	0.000123711	0	4.63918E-09	0.000237113	0
Y2		5.32319E-06	0	6.0076E-06	0	1.74905E-09	9.12548E-05	0
Y3		0.00001328	0	0.000288	0.00000608	0	0.000072	0
Z - TCE Equivalent in ug/L		4886.53	0.00	54930.04	799.52	0.84	52648.41	0.00

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011
DUMP ROAD AREA
LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND

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TABLE 4-3

	SAMPLE ID: LABORATORY ID: SAMPLE DATE:	5/19/2011	MW15D-051611 240-174-4 5/16/2011	MW15I-051611 240-174-3 5/16/2011	MW15S-051611 240-174-2 5/16/2011	MW15S-051611-A 240-174-2 5/16/2011	MW 16D-053111 9MJ1PQ10 5/31/2011	MW 16I-053111 9MJ1PN30 5/31/2011
VOLATILES (ug/l)	LOCATION:	DMW14I	MW15D	MW15I	MW15S	MW15S	MW 16D	MW 16I
CIS-1,2-DICHLOROETHENE		1200		380	20			
TRICHLOROETHENE		15 J		1500	63			
VINYL CHLORIDE		750		33 J	0.74 J			
Y1		1.23711E-05	0	3.91753E-06	2.06186E-07	0	0	0
Y2		1.14068E-07	0	1.14068E-05	4.79087E-07	0	0	0
Y3		0.000012	0	0.000000528	1.184E-08	0	0	0
Z - TCE Equivalent in ug/L		3219.80	0.00	2084.59	91.67	0.00	0.00	0.00

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 7 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	5/31/2011	MW16D-051811 240-271-4 5/18/2011 MW16D	MW16I-051811 240-271-3 5/18/2011 MW16I	MW16S-051811 240-271-2 5/18/2011 MW16S	MW17S-060611 240-813-2 6/6/2011 MW17S	DMW17I-051911 240-321-4 5/19/2011 DMW17I	MW18I-060611 240-813-5 6/6/2011 MW18I
VOLATILES (ug/l)								
CIS-1,2-DICHLOROETHENE				140 L	62 L	1.2	80	1300
TRICHLOROETHENE			0.6 J	590 L			480	11000
VINYL CHLORIDE				14	130 L	6.9	6.9 J	620
Y1		0	0	1.4433E-06	6.39175E-07	1.23711E-08	8.24742E-07	1.34021E-05
Y2		0	4.56274E-09	4.48669E-06	0	0	3.65019E-06	8.36502E-05
Y3		0	0	0.000000224	0.00000208	1.104E-07	1.104E-07	0.00000992
Z - TCE Equivalent in ug/L		0.00	0.60	809.25	357.57	16.14	602.97	14066.85

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011
DUMP ROAD AREA

TABLE 4-3

LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 8 OF 14

VOLATILES (ug/l)	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	6/6/2011	MW19D-060111 240-690-4 6/1/2011 MW19D	MW19I-060111 240-690-2 6/1/2011 MW19I	MW20D-051711 240-209-4 5/17/2011 MW20D	MW20I-051711 240-209-3 5/17/2011 MW20I	MW20S-051711 240-209-2 5/17/2011 MW20S	MW20S-051711-A 240-209-2 5/17/2011 MW20S
CIS-1,2-DICHLOROETHENE		280	0.59 J	150	1.7	460	1300	
TRICHLOROETHENE		2500	5.3	95	13	65	320	
VINYL CHLORIDE		110	0.27 J	73		220	840	
Y1		2.8866E-06	6.08247E-09	1.54639E-06	1.75258E-08	4.74227E-06	1.34021E-05	0
Y2		1.90114E-05	4.03042E-08	7.22433E-07	9.88593E-08	4.94297E-07	2.43346E-06	0
Y3		0.00000176	4.32E-09	0.000001168	0	0.00000352	0.00001344	0
Z - TCE Equivalent in ug/L		3111.03	6.67	451.94	15.30	1151.49	3849.73	0.00

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 9 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	240-209-2 5/17/2011	MW22D-060211 240-726-6 6/2/2011 MW22D	MW23D-060211 240-726-4 6/2/2011 MW23D	MW23S-060211 240-726-2 6/2/2011 MW23S	MW24I-060211 240-726-5 6/2/2011 MW24I	MW24S-060211 240-726-3 6/2/2011 MW24S	MW25I-060311 240-774-2 6/3/2011 MW25I
VOLATILES (ug/l)				_				
CIS-1,2-DICHLOROETHENE					3			
TRICHLOROETHENE			0.48 J	1.6		110		
VINYL CHLORIDE					12			
Y1		0	0	0	3.09278E-08	0	0	0
Y2		0	3.65019E-09	1.21673E-08	0	8.36502E-07	0	0
Y3		0	0	0	0.000000192	0	0	0
Z - TCE Equivalent in ug/L		0.00	0.48	1.60	29.32	110.00	0.00	0.00

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011
DUMP ROAD AREA

LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 10 OF 14

TABLE 4-3

VOLATILES (ug/l)	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	MW25I-060611 R1103161-009 6/6/2011 MW25I	MW25S-060311 240-774-3 6/3/2011 MW25S	MW25S-060611 R1103161-008 6/6/2011 MW25S	MW26S-053111 240-626-5 5/31/2011 MW26S	MW26S-053111RA 240-626-5 5/31/2011 MW26S	MW27D-060611 240-813-4 6/6/2011 MW27D	MW27D-60611 9MJ5J720 6/6/2011 MW27D
CIS-1,2-DICHLOROETHENE			200		12			
TRICHLOROETHENE			56					
VINYL CHLORIDE			10		35			
Y1		0	2.06186E-06	0	1.23711E-07	0	0	0
Y2		0	4.25856E-07	0	0	0	0	0
Y3		0	0.00000016	0	0.00000056	0	0	0
Z - TCE Equivalent in ug/L		0.00	348.17	0.00	89.91	0.00	0.00	0.00

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 11 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE:	MW28I-060611 240-813-7 6/6/2011	MW29D-060911 240-979-7 6/9/2011	MW30D-060811 240-914-5 6/8/2011	MW31D-060811 240-914-3 6/8/2011	MW32I -053111 R1103025-005 5/31/2011	MW32I-053111 240-626-9 5/31/2011	MW32S-053111 240-626-7 5/31/2011
	LOCATION:	MW28I	MW29D	MW30D	MW31D	MW32I	MW32I	MW32S
VOLATILES (ug/l)								
CIS-1,2-DICHLOROETHENE		570						
TRICHLOROETHENE		1100						
VINYL CHLORIDE		72						
Y1		5.87629E-06	0	0	0	0	0	0
Y2		8.36502E-06	0	0	0	0	0	0
Y3		0.000001152	0	0	0	0	0	0
Z - TCE Equivalent in ug/L		2024.22	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 12 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE:	MSA-MW33I- 052611 240-569-5 5/26/2011	MSA-MW33S- 052611 240-569-4 5/26/2011	MW34I-060911 240-979-3 6/9/2011	MW34S-060911 240-979-2 6/9/2011	MSA-MW30I-062911 240-1591-2 6/29/2011	MSA-MW-35S-062811 240-1564-2 6/28/2011	MSA-MW3 240-1 7/5/2
	LOCATION:	MSA-MW33I	MSA-MW33S	MW34I	MW34S	MSA-MW30I	MSA-MW-35S	MSA-N
VOLATILES (ug/l)								
CIS-1,2-DICHLOROETHENE			3.4	3.5	2.2		7.7	
TRICHLOROETHENE			5.3			490	3.4	
VINYL CHLORIDE				32	1.2		1.5	
Y1		0	3.50515E-08	3.60825E-08	2.26804E-08	0	7.9381E-08	0
Y2		0	4.03042E-08	0	0	3.7262E-06	2.5856E-08	0
Y3		0	0	0.000000512	1.92E-08	0	2.4000E-08	0
Z - TCE Equivalent in ug/L		0.00	9.91	72.07	5.51	490	16.99	0

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011 DUMP ROAD AREA LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND PAGE 13 OF 14

VOLATILES (ug/l)	SAMPLE ID: LABORATORY ID: SAMPLE DATE: LOCATION:	702-1 2011	MSA-MW-37S-062811 240-1564-3 6/28/2011 MSA-MW-37S	MSA-MW38S-062911 240-1591-1 6/29/2011 MSA-MW38S	MSA-MW-39S-062811 240-1564-1 6/28/2011 MSA-MW-39S	DMW7S 2007	DMW7I 2007	DMW7D 2008
CIS-1,2-DICHLOROETHENE					15	24100	282	0
TRICHLOROETHENE					12	8050	311	0.46
VINYL CHLORIDE					12	1250	59.7	0
Y1			0	0	1.5464E-07	0.000248454	2.90722E-06	0
Y2			0	0	9.1255E-08	6.12167E-05	2.36502E-06	3.4981E-09
Y3			0	0	1.9200E-07	0.00002	9.552E-07	0
Z - TCE Equivalent in ug/L			0	0	57.58	43351.65	818.91	0.46

TABLE 4-3

CHEMICAL RESULTS FOR GROUNDWATER SAMPLES, MAY-JUNE 2011

DUMP ROAD AREA

LOCKHEED MARTIN, MARTIN STATE AIRPORT, MIDDLE RIVER, MARYLAND
PAGE 14 OF 14

	SAMPLE ID: LABORATORY ID: SAMPLE DATE:	DMW5D	DMW5D DMW5	DMW2B	MW-2 Intermediate	EP1-SD-5
	LOCATION:	2007	2008	2007		
VOLATILES (ug/l)						
CIS-1,2-DICHLOROETHENE		0	0	6.5	13	28200
TRICHLOROETHENE		2	1.1	4.5	6.8	270000
VINYL CHLORIDE		0	0	0	9.3	0
Y1				6.70103E-08	1.34021E-07	0.000290722
Y2				3.42205E-08	5.1711E-08	0.002053232
Y3				0	1.488E-07	0
Z - TCE Equivalent in ug/L		2.00	1.10	13.31	43.99	308229.90

TCE-Equiv-Original

	2009					2010				201:	l
SAMPLE ID:	EASTING	NORTHING	Z		SAMPLE ID:	EASTING	NORTHING	Z	SAMPLE	ID: EASTING	NORTHING Z
									MW2		43.99
MW3	1479107.13	604448.6	33.53	S	MW3	1479107.13	604448.6	60.55	MW3	1479107.1	8 604448.6 17.96
MW4	1479180.77	604852.95	4.35	S	MW4	1479180.77	604852.95	1.49	MW4	1479180.7	
MW5	1479901.65	604294.92	4915.77	S	MW5	1479901.65	604294.92	3718.87	MW5	1479901.6	604294.92 5560.44
MW6	1480185.27	604009.29	1.6	S	MW6	1480185.27	604009.29	0.43	MW6	1480185.2	7 604009.29 0
DMW1A	1479498.31	604398.93	20495.36	1	DMW1A	1479498.31	604398.93		DMW1A	1479498.3	1 604398.93 16893.02
DMW1B	1479498.68	604399.15	9634.81	D	DMW1B	1479498.68	604399.15	5958.23	DMW1B	1479498.6	
DMW1S	1479310.93	604458.71	52.08	S	DMW1S	1479310.93	604458.71	1003.57	DMW1S	1479310.9	
DMW2A	1479789.18	604678.89	24458.79	1	DMW2A	1479789.18	604678.89		DMW2A	1479789.1	
DMW2B	1479789.39	604678.82	NS	D	DMW2B	1479789.39	604678.82	NS	DMW2B	1479789.3	
DMW2S	1479807.82	604670.26	4609.08	S	DMW2S	1479807.82	604670.26		DMW2S	1479807.8	
DMW3D	1479731.58	604810.35	0.97	D	DMW3D	1479731.58	604810.35	0.57	DMW3D	1479731.5	
DMW3I	1479731.67		49041.59	I I	DMW3I	1479731.67	604810.23		DMW3I	1479731.6	
DMW3S	1479731.67	604810.23	5496.97	S	DMW3S	1479731.67	604810.23	5885.73	DMW3S	1479731.6	
DMW4D	1480030.83	604566.02	6342.27	D	DMW4D	1480030.83	604566.02	5537.16	DMW4D	1480030.8	
DMW4I	1480031.07	604565.89	8941.47	I I	DMW4I	1480031.07	604565.89	8377.17	DMW4I	1480031.0	
DMW4S	1480035.76	604562.77	870.53	S	DMW4S	1480035.76	604562.77	1029.79	DMW4S	1480035.7	
DMW5D	148140.63	604431.1	NS	D	DMW5D	148140.63	604431.1	NS	DMW5D	148140.6	
DMW5I	1480140.5	604419.87	50.52	I I	DMW5I	1480140.5	604419.87	177.88	DMW5I	1480140	
DMW5S	1480141.08	604415.6	10328.56	S	DMW5S	1480141.08	604415.6	11626.8	DMW5S	1480141.0	
DMW6D	1480266.04	604193.88	0	D	DMW6D	1480266.04	604193.88	0	DMW6D	1480266.0	
DMW6I	1480265.8	604193.89	0	I I	DMW6I	1480265.8	604193.89	0	DMW6I	1480265.	
DMW6S	1480255.25	604190.24	4.49	S	DMW6S	1480255.25	604190.24	3.21	DMW6S	1480255.2	
DMW7D	1479924.19	604287.20	NS	D	DMW7D	1479924.19	604287.20	NS	DMW7D	1479924.1	
DMW7I	1479924.19	604287.20	NS	I I	DMW7I	1479924.19	604287.20	NS	DMW7I	1479924.1	
DMW7S	1479921.81	604291.49	NS	S	DMW7S	1479921.81	604291.49	NS	DMW7S	1479921.8	
DMW8D	1479673.19	604516.37	2472.65	D	DMW8D	1479673.19	604516.37	2903.25	DMW8D	1479673.1	
DMW8I	1479673.3	604516.63	2197.99	I	DMW8I	1479673.3	604516.63	1263.61	DMW8I	1479673.	
DMW8S	1479667.65	604517.11	1.99	S	DMW8S	1479667.65	604517.11	1.68	DMW8S	1479667.6	
DMW9D	1479293.89	604764.94	4724.36	D	DMW9D	1479293.89	604764.94	3919.22	DMW9D	1479293.8	
DMW9I	1479293.73	604764.96	8191.61	I	DMW9I	1479293.73	604764.96	9236.14	DMW9I	1479293.7	
DMW9S	1479287.27	604771.52		S	DMW9S	1479287.27	604771.52		DMW9S	1479287.2	
DMW10S	1479225.84	604636.66	294.56	S	DMW10S	1479225.84	604636.66	420.8	DMW10S		
DMW10I	1479217.34	604630.69	NS	I	DMW10I	1479217.34	604630.69	NS	DMW10I		
DMW11I	1478934.94	604423.96	1.73	Į.	DMW11I	1478934.94	604423.96	1.21	DMW11I		
DMW11S	1478930.78	604429.32	100208.9	S	DMW11S	1478930.78	604429.32		DMW119		
MW14D	1479550.682	605129.8548	0	DD	MW14D	1479550.682	605129.8548	0	MW14D	1479550.68	
MW14I	1479550.682	605129.8548	3757.13	1	MW14I	1479550.682	605129.8548	2657.84	MW14I	1479550.68	
MW15D	1479028.294	605010.9613	0	D	MW15D	1479028.294	605010.9613	0	MW15D	1479028.29	
MW15I	1479028.294	605010.9613		1	MW15I	1479028.294	605010.9613	782.81	MW15I	1479028.29	
MW15S	1479028.294	605010.9613	1404.84	S	MW15S	1479028.294	605010.9613	949.8	MW15S	1479028.29	
MW16D	1479248.844		0	D	MW16D	1479248.844	605086.4229	0	MW16D	1479248.84	
MW16I	1479248.844	605086.4229	664.12	I	MW16I	1479248.844	605086.4229	892.02	MW16I	1479248.84	
MW16S	1479248.844	605086.4229	101.65	S	MW16S	1479248.844	605086.4229	86.59	MW16S	1479248.84	
MW17I	1479358.318		412.16	ı	MW17I	1479358.318	605112.6691	821.5	MW17I	1479358.31	
MW17S	1479358.318	605112.6691	2.19	S	MW17S	1479358.318	605112.6691	3.35	MW17S	1479358.31	
MW18D	1479642.312	604934.535	NS	D	MW18D	1479642.312	604934.535	NS	MW18D	1479642.31	
MW18I	1479645.061	604930.7721	14858.84	ı	MW18I	1479645.061	604930.7721		MW18I	1479645.06	
MW18S	1479645.061	604930.7721	5027.6	S	MW18S	1479645.061	604930.7721	39.66	MW18S	1479645.06	
MW19D	14/9/01.179	604152.7014	3.7	D	MW19D	1479701.179	604152.7014	4.4	MW19D	1479701.17	9 604152.7014 6.67

TCE-Equiv-Original

	2009					2010				2011		
SAMPLE ID:	EASTING	NORTHING	Z		SAMPLE ID:	EASTING	NORTHING 2	7_	SAMPLE I	D: EASTING	NORTHING Z	7_
MW19I	1479701.179	604152.7014	521.13	1	MW19I	1479701.179	604152.7014	687.17	MW19I	1479701.179	604152.7014	451.94
MW20D	1479397.945	604630.9616	30.9	D	MW20D	1479397.945	604630.9616	18.44	MW20D	1479397.945	604630.9616	15.3
MW20I	1479397.945	604630.9616	591.32	1	MW20I	1479397.945	604630.9616	788.45	MW20I	1479397.945	604630.9616	1151.49
MW20S	1479397.945	604630.9616	5244.94	S	MW20S	1479397.945	604630.9616	6322.84	MW20S	1479397.945	604630.9616	3849.73
MW2ID	1479303.22	604467.75	NS	D	MW2ID	1479303.22	604467.75	NS	MW2ID	1479303.22	604467.75	NS
MW21I	1479303.22	604467.75	NS	1	MW21I	1479303.22	604467.75	NS	MW21I	1479303.22	604467.75	NS
MW22D	1479112.839	604442.0743	0	D	MW22D	1479112.839	604442.0743	0.81	MW22D	1479112.839	604442.0743	0.48
MW22I	1479112.84	604442.07	NS	1	MW22I	1479112.84	604442.07	NS	MW22I	1479112.84	604442.07	NS
MW23D	1479295.124	604237.1317	0.91	D	MW23D	1479295.124	604237.1317	0.92	MW23D	1479295.124	604237.1317	1.6
MW23S	1479295.124	604237.1317	33.24	S	MW23S	1479295.124	604237.1317	33.24	MW23S	1479295.124	604237.1317	29.32
MW23I	1479295.12	604237.13	NS	1	MW23I	1479295.12	604237.13	NS	MW23I	1479295.12	604237.13	NS
MW24I	1479375.239	603945.6639	54	1	MW24I	1479375.239	603945.6639	69	MW24I	1479375.239	603945.6639	110
MW24S	1479375.239	603945.6639	0	S	MW24S	1479375.239	603945.6639	0	MW24S	1479375.239	603945.6639	0
MW25I	1478812.441	604510.0829	0.3	1	MW25I	1478812.441	604510.0829	0	MW25I	1478812.441	604510.0829	0
MW25S	1478812.441	604510.0829	11.36	S	MW25S	1478812.441	604510.0829	349.15	MW25S	1478812.441	604510.0829	348.17
MW26D	1479035.39	604726.41	NS	D	MW26D	1479035.39	604726.41	NS	MW26D	1479035.39	604726.41	NS
MW26I	1479035.39	604726.41	NS	1	MW26I	1479035.39	604726.41	NS	MW26I	1479035.39	604726.41	NS
MW26S	1479035.393	604726.4128	408.44	S	MW26S	1479035.393	604726.4128	240.69	MW26S	1479035.393	604726.4128	89.91
MW27D	1479032	605114.25	0	DD	MW27D	1479032	605114.25	0	MW27D	1479032	605114.25	0
MW28I	1479027.89	605110.61	1021.79	1	MW28I	1479027.89	605110.61	2062.79	MW28I	1479027.89	605110.61	2024.22
MW29D	1480488.41	603774.77	0	DD	MW29D	1480488.41	603774.77	0	MW29D	1480488.41	603774.77	0
MW30D	1479645.71	603825.46	0	DD	MW30D	1479645.71	603825.46	0	MW30D	1479645.71	603825.46	0
MW31D	1480099.58	603747.78	0	DD	MW31D	1480099.58	603747.78	0	MW31D	1480099.58	603747.78	0
MW32I	1479930.711	603917.9149	0	1	MW32I	1479930.711	603917.9149	0	MW32I	1479930.711	603917.9149	0
MW32S	1479930.711	603917.9149	0	S	MW32S	1479930.711	603917.9149	0	MW32S	1479930.711	603917.9149	0
MW33I	1478763.31	605117.6822	2.56	1	MW33I	1478763.31	605117.6822	2.44	MW33I	1478763.31	605117.6822	0
MW33S	1478763.31	605117.6822	3421.36	S	MW33S	1478763.31	605117.6822	2349.56	MW33S	1478763.31	605117.6822	9.91
MW34I	1478890.17	605355.017	33.59	1	MW34I	1478890.17	605355.017	33.86	MW34I	1478890.17	605355.017	72.07
MW34S	1478890.17	605355.017	5.61	S	MW34S	1478890.17	605355.017	4.19	MW34S	1478890.17	605355.017	5.51
MW17D	1479358.32	605112.67	0	1					MW30I	1479473.540	603824.910	490
				S					MW35S	1478645.770	605371.560	16.99
				S					MW36S	1478395.880	605068.520	0
				S					MW37S	1478851.690	604275.330	0
				S					MW38S	1478555.270	604045.940	0
				S					MW39S	1479561.570	604711.980	57.58

	2009					2010		
SAMPLE ID:	EASTING	NORTHING	Z		SAMPLE ID:	EASTING	NORTHING	Z
DMW10S	1479225.84	604636.66	294.56	S	DMW10S	1479225.84		420.8
DMW11S	1478930.78	604429.32		S	DMW11S	1478930.78		
DMW1S	1479310.93	604458.71	52.08	S	DMW1S	1479310.93		1003.57
DMW2S	1479807.82	604670.26	4609.08	S	DMW2S	1479807.82		
DMW3S	1479731.67	604810.23	5496.97	S	DMW3S	1479731.67		5885.73
DMW4S	1480035.76	604562.77	870.53	S	DMW4S	1480035.76	604562.77	1029.79
DMW5S	1480141.08	604415.6	10328.56	S	DMW5S	1480141.08	604415.6	11626.8
DMW6S	1480255.25	604190.24	4.49	S	DMW6S	1480255.25	604190.24	3.21
DMW7S	1479921.81	604291.49	43351.65	S	DMW7S	1479921.81	604291.49	43351.65
DMW8S	1479667.65	604517.11	1.99	S	DMW8S	1479667.65	604517.11	1.68
DMW9S	1479287.27	604771.52	126771.4	S	DMW9S	1479287.27	604771.52	80743.71
MW15S	1479028.294	605010.9613	1404.84	S	MW15S	1479028.294	605010.9613	949.8
MW16S	1479248.844	605086.4229	101.65	S	MW16S	1479248.844	605086.4229	86.59
MW17S	1479358.318	605112.6691	2.19	S	MW17S	1479358.318	605112.6691	3.35
MW18S	1479645.061	604930.7721	5027.6	S	MW18S	1479645.061	604930.7721	39.66
MW20S	1479397.945	604630.9616	5244.94	S	MW20S	1479397.945	604630.9616	6322.84
MW23S	1479295.124	604237.1317	33.24	S	MW23S	1479295.124	604237.1317	33.24
MW24S	1479375.239	603945.6639	0	S	MW24S	1479375.239	603945.6639	0
MW25S	1478812.441	604510.0829	11.36	S	MW25S	1478812.441	604510.0829	349.15
MW26S	1479035.393	604726.4128	408.44	S	MW26S	1479035.393	604726.4128	240.69
MW3	1479107.13	604448.6	33.53	S	MW3	1479107.13	604448.6	60.55
MW32S	1479930.711	603917.9149	0	S	MW32S	1479930.711	603917.9149	0
MW33S	1478763.31	605117.6822	3421.36	S	MW33S	1478763.31	605117.6822	2349.56
MW34S	1478890.17	605355.017	5.61	S	MW34S	1478890.17	605355.017	4.19
MW4	1479180.77	604852.95	4.35	S	MW4	1479180.77	604852.95	1.49
MW5	1479901.65	604294.92	4915.77	S	MW5	1479901.65	604294.92	3718.87
MW6	1480185.27	604009.29	1.6	S	MW6	1480185.27	604009.29	0.43
				S				
				S				
				S				
				S				

	2009					2010		
SAMPLE ID:	EASTING	NORTHING	Z		SAMPLE ID:	EASTING	NORTHING	Z
				S				
DMW10I	1479217.34	604630.69	700.67	1	DMW10I	1479217.34	604630.69	700.67
DMW11I	1478934.94	604423.96	1.73	1	DMW11I	1478934.94	604423.96	1.21
DMW1A	1479498.31	604398.93	20495.36	1	DMW1A	1479498.31	604398.93	11478.68
DMW2A	1479789.18	604678.89	24458.79	1	DMW2A	1479789.18	604678.89	20696.79
DMW3I	1479731.67	604810.23	49041.59	1	DMW3I	1479731.67	604810.23	33382.77
DMW4I	1480031.07	604565.89	8941.47	1	DMW4I	1480031.07	604565.89	8377.17
DMW5I	1480140.5	604419.87	50.52	1	DMW5I	1480140.5	604419.87	177.88
DMW6I	1480265.8	604193.89	0	1	DMW6I	1480265.8	604193.89	0
DMW7I	1479924.19	604287.20	818.91	1	DMW7I	1479924.19	604287.20	818.91
DMW8I	1479673.3	604516.63	2197.99	1	DMW8I	1479673.3	604516.63	1263.61
DMW9I	1479293.73	604764.96	8191.61	1	DMW9I	1479293.73	604764.96	9236.14
MW14I	1479550.682	605129.8548	3757.13	1	MW14I	1479550.682	605129.8548	2657.84
MW15I	1479028.294	605010.9613	10107.03	1	MW15I	1479028.294	605010.9613	782.81
MW16I	1479248.844	605086.4229	664.12	1	MW16I	1479248.844	605086.4229	892.02
MW17I	1479358.318	605112.6691	412.16	1	MW17I	1479358.318	605112.6691	821.5
MW18I	1479645.061	604930.7721	14858.84	1	MW18I	1479645.061	604930.7721	10140.76
MW19I	1479701.179	604152.7014	521.13	1	MW19I	1479701.179	604152.7014	687.17
MW20I	1479397.945	604630.9616	591.32	1	MW20I	1479397.945	604630.9616	788.45
MW21I	1479303.22	604467.75	1632.57	1	MW21I	1479303.22	604467.75	1632.57
MW22I	1479112.84	604442.07	4.01	1	MW22I	1479112.84	604442.07	4.01
MW23I	1479295.12	604237.13	100.68	1	MW23I	1479295.12	604237.13	100.68
MW24I	1479375.239	603945.6639	54	1	MW24I	1479375.239	603945.6639	69
MW25I	1478812.441	604510.0829	0.3	1	MW25I	1478812.441	604510.0829	0
MW26I	1479035.39	604726.41	3.94	1	MW26I	1479035.39	604726.41	3.94
MW28I	1479027.89	605110.61	1021.79	1	MW28I	1479027.89	605110.61	2062.79
MW32I	1479930.711	603917.9149	0	1	MW32I	1479930.711	603917.9149	0
MW33I	1478763.31	605117.6822	2.56	1	MW33I	1478763.31	605117.6822	2.44
MW34I	1478890.17	605355.017	33.59	1	MW34I	1478890.17	605355.017	33.86
				1				
MW14D	1479550.682	605129.8548	0	DD	MW14D	1479550.682	605129.8548	0
MW27D	1479032	605114.25	0	DD	MW27D	1479032	605114.25	0

	2009					2010		
SAMPLE ID:	EASTING	NORTHING	Z		SAMPLE ID:	EASTING	NORTHING	Z
MW29D	1480488.41	603774.77	0	DD	MW29D	1480488.41	603774.77	0
MW30D	1479645.71	603825.46	0	DD	MW30D	1479645.71	603825.46	0
MW31D	1480099.58	603747.78	0	DD	MW31D	1480099.58	603747.78	0
DMW1B	1479498.68	604399.15	9634.81	D	DMW1B	1479498.68	604399.15	5958.23
DMW2B	1479789.39	604678.82	13.31	D	DMW2B	1479789.39	604678.82	13.31
DMW3D	1479731.58	604810.35	0.97	D	DMW3D	1479731.58	604810.35	0.57
DMW4D	1480030.83	604566.02	6342.27	D	DMW4D	1480030.83	604566.02	5537.16
DMW5D	148140.63	604431.1	2	D	DMW5D	148140.63	604431.1	2
DMW6D	1480266.04	604193.88	0	D	DMW6D	1480266.04	604193.88	0
DMW7D	1479924.19	604287.20	0.46	D	DMW7D	1479924.19	604287.20	0.46
DMW8D	1479673.19	604516.37	2472.65	D	DMW8D	1479673.19	604516.37	2903.25
DMW9D	1479293.89	604764.94	4724.36	D	DMW9D	1479293.89	604764.94	3919.22
MW15D	1479028.294	605010.9613	0	D	MW15D	1479028.294	605010.9613	0
MW16D	1479248.844	605086.4229	0	D	MW16D	1479248.844	605086.4229	0
MW18D	1479642.312	604934.535	7.48	D	MW18D	1479642.312	604934.535	7.48
MW19D	1479701.179	604152.7014	3.7	D	MW19D	1479701.179	604152.7014	4.4
MW20D	1479397.945	604630.9616	30.9	D	MW20D	1479397.945	604630.9616	18.44
MW22D	1479112.839	604442.0743	0	D	MW22D	1479112.839	604442.0743	0.81
MW23D	1479295.124	604237.1317	0.91	D	MW23D	1479295.124	604237.1317	0.92
MW26D	1479035.39	604726.41	7.01	D	MW26D	1479035.39	604726.41	7.01
MW2ID	1479303.22	604467.75	0	D	MW2ID	1479303.22	604467.75	0
MW17D	1479358.32	605112.67	0		MW17D	1479358.32	605112.67	0

2011

2011				
SAMPLE ID:	EASTING I	NORTHING	Z	
DN 414/4/05	4.470225.04	504535.55	700 53	
DMW10S	1479225.84	604636.66	799.52	
DMW11S	1478930.78	604429.32	52648.41	
DMW1S	1479310.93	604458.71	159.93	
DMW2S	1479807.82	604670.26	5420.88	
DMW3S	1479731.67	604810.23	7457.27	
DMW4S	1480035.76	604562.77	1430.01	
DMW5S	1480141.08	604415.6	11333.51	
DMW6S	1480255.25	604190.24	2.7	
DMW7S	1479921.81	604291.49	43351.65	
DMW8S	1479667.65	604517.11	0.53	
DMW9S	1479287.27	604771.52	54930.04	
MW15S	1479028.294	605010.9613	91.67	
MW16S	1479248.844	605086.4229	357.57	
MW17S	1479358.318	605112.6691	16.14	
MW18S	1479645.061	604930.7721	3111.03	
MW20S	1479397.945	604630.9616	3849.73	
MW23S	1479295.124	604237.1317	29.32	
MW24S	1479375.239	603945.6639	0	
MW25S	1478812.441	604510.0829	348.17	
MW26S	1479035.393	604726.4128	89.91	
MW3	1479107.13	604448.6	17.96	
MW32S	1479930.711	603917.9149	0	
MW33S	1478763.31	605117.6822	9.91	
MW34S	1478890.17	605355.017	5.51	
MW4	1479180.77	604852.95	0	
MW5	1479901.65	604294.92	5560.44	
MW6	1480185.27	604009.29	0	
MW35S	1478645.770000	605371.560000	16.99	
MW36S	1478395.880000	605068.520000	0	
MW37S	1478851.690000	604275.330000	0	
MW38S	1478555.270000	604045.940000	0	

2011

SAMPLE ID:	EASTING	NORTHING	Z
MW39S	1479561.570000	604711.980000	57.58
DMW10I	1479217.34	604630.69	700.67
DMW11I	1478934.94	604423.96	0.84
DMW1A	1479498.31	604398.93	16893.02
DMW2A	1479789.18	604678.89	19804.38
DMW3I	1479731.67	604810.23	30784.16
DMW4I	1480031.07	604565.89	7550.91
DMW5I	1480140.5	604419.87	197.09
DMW6I	1480265.8	604193.89	0
DMW7I	1479924.19	604287.20	818.91
DMW8I	1479673.3	604516.63	2061.18
DMW9I	1479293.73	604764.96	4886.53
MW14I	1479550.682	605129.8548	3219.8
MW15I	1479028.294	605010.9613	2084.59
MW16I	1479248.844	605086.4229	809.25
MW17I	1479358.318	605112.6691	602.97
MW18I	1479645.061	604930.7721	14066.85
MW19I	1479701.179	604152.7014	451.94
MW20I	1479397.945	604630.9616	1151.49
MW21I	1479303.22	604467.75	1632.57
MW22I	1479112.84	604442.07	4.01
MW23I	1479295.12	604237.13	100.68
MW24I	1479375.239	603945.6639	110
MW25I	1478812.441	604510.0829	0
MW26I	1479035.39	604726.41	3.94
MW28I	1479027.89	605110.61	2024.22
MW32I	1479930.711	603917.9149	0
MW33I	1478763.31	605117.6822	0
MW34I	1478890.17	605355.017	72.07
MW30I	1479473.540000	603824.910000	490
MW14D	1479550.682	605129.8548	0
MW27D	1479032	605114.25	0

2011

SAMPLE ID:	EASTING	NORTHING	Z
MW29D	1480488.41	603774.77	0
MW30D	1479645.71	603825.46	0
MW31D	1480099.58	603747.78	0
DMW1B	1479498.68	604399.15	7600.81
DMW2B	1479789.39	604678.82	13.31
DMW3D	1479731.58	604810.35	4.7
DMW4D	1480030.83	604566.02	4755.82
DMW5D	148140.63	604431.1	2
DMW6D	1480266.04	604193.88	0
DMW7D	1479924.19	604287.20	0.46
DMW8D	1479673.19	604516.37	3046.6
DMW9D	1479293.89	604764.94	3405.63
MW15D	1479028.294	605010.9613	0
MW16D	1479248.844	605086.4229	0
MW18D	1479642.312	604934.535	7.48
MW19D	1479701.179	604152.7014	6.67
MW20D	1479397.945	604630.9616	15.3
MW22D	1479112.839	604442.0743	0.48
MW23D	1479295.124	604237.1317	1.6
MW26D	1479035.39	604726.41	7.01
MW2ID	1479303.22	604467.75	0
MW17D	1479358.32	605112.67	0

TCE-Equiv 2011S

DMW10S	1479225.84	604636.66	799.52
DMW11S	1478930.78	604429.32	52648.41
DMW1S	1479310.93	604458.71	159.93
DMW2S	1479807.82	604670.26	5420.88
DMW3S	1479731.67	604810.23	7457.27
DMW4S	1480035.76	604562.77	1430.01
DMW5S	1480141.08	604415.6	11333.51
DMW6S	1480255.25	604190.24	2.7
DMW7S	1479921.81	604291.49	43351.65
DMW8S	1479667.65	604517.11	0.53
DMW9S	1479287.27	604771.52	54930.04
MW15S	1479028.294	605010.9613	91.67
MW16S	1479248.844	605086.4229	357.57
MW17S	1479358.318	605112.6691	16.14
MW18S	1479645.061	604930.7721	3111.03
MW20S	1479397.945	604630.9616	3849.73
MW23S	1479295.124	604237.1317	29.32
MW24S	1479375.239	603945.6639	0
MW25S	1478812.441	604510.0829	348.17
MW26S	1479035.393	604726.4128	89.91
MW3	1479107.13	604448.6	17.96
MW32S	1479930.711	603917.9149	0
MW33S	1478763.31	605117.6822	9.91
MW34S	1478890.17	605355.017	5.51
MW4	1479180.77	604852.95	0
MW5	1479901.65	604294.92	5560.44
MW6	1480185.27	604009.29	0
MW35S	1478645.770000	605371.560000	16.99
MW36S	1478395.880000	605068.520000	0
MW37S	1478851.690000	604275.330000	0
MW38S	1478555.270000	604045.940000	0
MW39S	1479561.570000	604711.980000	57.58

TCE-Equiv 2011I

1479217.34	604630.69	700.67
4.470024.04		
1478934.94	604423.96	0.84
1479498.31	604398.93	16893.02
1479789.18	604678.89	19804.38
1479731.67	604810.23	30784.16
1480031.07	604565.89	7550.91
1480140.5	604419.87	197.09
1480265.8	604193.89	0
1479924.19	604287.20	818.91
1479673.3	604516.63	2061.18
1479293.73	604764.96	4886.53
1479550.682	605129.8548	3219.8
1479028.294	605010.9613	2084.59
1479248.844	605086.4229	809.25
1479358.318	605112.6691	602.97
1479645.061	604930.7721	14066.85
1479701.179	604152.7014	451.94
1479397.945	604630.9616	1151.49
1479303.22	604467.75	1632.57
1479112.84	604442.07	4.01
1479295.12	604237.13	100.68
1479375.239	603945.6639	110
1478812.441	604510.0829	0
1479035.39	604726.41	3.94
1479027.89	605110.61	2024.22
1479930.711	603917.9149	0
1478763.31	605117.6822	0
1478890.17	605355.017	72.07
1479473.540000	603824.910000	490
	1479498.31 1479789.18 1479731.67 1480031.07 1480140.5 1480265.8 1479924.19 1479673.3 1479293.73 1479550.682 1479028.294 1479248.844 1479358.318 1479645.061 1479701.179 1479397.945 1479303.22 1479112.84 1479295.12 1479375.239 1478812.441 1479035.39 1479027.89 1479930.711 1478763.31 1478890.17	1479498.31604398.931479789.18604678.891479731.67604810.231480031.07604565.891480140.5604419.871480265.8604193.891479924.19604287.201479673.3604516.631479293.73604764.961479550.682605129.85481479028.294605010.96131479348.844605086.42291479358.318605112.66911479645.061604930.77211479701.179604152.70141479303.22604467.751479112.84604442.071479295.12604237.131479375.239603945.66391478812.441604510.08291479027.89605110.611479930.711603917.91491478763.31605355.017

MW14D	1479550.682	605129.8548	0
MW27D	1479032	605114.25	0
MW29D	1480488.41	603774.77	0
MW30D	1479645.71	603825.46	0
MW31D	1480099.58	603747.78	0
DMW1B	1479498.68	604399.15	7600.81
DMW2B	1479789.39	604678.82	13.31
DMW3D	1479731.58	604810.35	4.7
DMW4D	1480030.83	604566.02	4755.82
DMW5D	1480140.63	604431.1	2
DMW6D	1480266.04	604193.88	0
DMW7D	1479924.19	604287.20	0.46
DMW8D	1479673.19	604516.37	3046.6
DMW9D	1479293.89	604764.94	3405.63
MW15D	1479028.294	605010.9613	0
MW16D	1479248.844	605086.4229	0
MW17D	1479358.32	605112.67	0
MW18D	1479642.312	604934.535	7.48
MW19D	1479701.179	604152.7014	6.67
MW20D	1479397.945	604630.9616	15.3
MW22D	1479112.839	604442.0743	0.48
MW23D	1479295.124	604237.1317	1.6
MW26D	1479035.39	604726.41	7.01
MW2ID	1479303.22	604467.75	0